

(19)



(11)

EP 2 587 980 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:

06.01.2016 Bulletin 2016/01

(51) Int Cl.:

A47L 9/20 *(2006.01)*

A47L 9/16 *(2006.01)*

(86) International application number:

PCT/GB2011/051129

(21) Application number: **11727283.1**

(22) Date of filing: **16.06.2011**

(87) International publication number:

WO 2012/001387 (05.01.2012 Gazette 2012/01)

(54) **CYCLONE VACUUM CLEANER**

ZYKLON-STAUBSAUGER

ASPIRATEUR À CYCLONES

(84) Designated Contracting States:

**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

(30) Priority: **30.06.2010 GB 201010955**

(43) Date of publication of application:

08.05.2013 Bulletin 2013/19

(73) Proprietor: **Dyson Technology Limited
Malmesbury, Wiltshire SN16 0RP (GB)**

(72) Inventors:

- **NICOLAOU, Richard
Malmesbury
Wiltshire SN16 0RP (GB)**

• **FOLLOWS, Thomas**

**Malmesbury
Wiltshire SN16 0RP (GB)**

• **SYMES, Ashley**

**Malmesbury
Wiltshire SN16 0RP (GB)**

(74) Representative: **Fountain, Sullivan et al**

**Dyson Technology Limited
Tetbury Hill
GB-Malmesbury, Wiltshire SN16 0RP (GB)**

(56) References cited:

**EP-A1- 0 476 169 EP-A2- 1 136 028
US-A- 2 521 380**

EP 2 587 980 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description

[0001] This invention relates to a surface treating appliance, and in particular to a vacuum cleaner comprising at least one cyclone.

[0002] Surface treating appliances, for example vacuum cleaners, can separate dirt and dust from an airflow without the use of a filter bag. These so-called bagless vacuum cleaners are very popular. Most bagless vacuum cleaners use cyclonic or centrifugal separation to spin dirt and dust from the airflow. By avoiding the use of a filter bag as the primary form of separation, it has been found to be possible to maintain a consistently high level of suction, even as the collecting chamber fills with dirt.

[0003] The principle of cyclonic separation in domestic vacuum cleaners is described in a number of publications including EP 0 042 723. In general, an airflow in which dirt and dust is entrained enters a first cyclonic separator via a tangential inlet which causes the airflow to follow a spiral or helical path within a collection chamber so that the dirt and dust is separated from the airflow. Relatively clean air passes out of the chamber whilst the separated dirt and dust is collected therein. In some applications, the airflow is then passed through a second and possibly a third stage of cyclonic separation which is capable of separating finer dirt and dust than the upstream cyclone. The airflow is thereby cleaned to a greater degree so that, by the time the airflow exits the cyclonic separating apparatus, the airflow is almost completely free of dirt and dust particles.

[0004] Small cyclones can be desirable as they may be able to separate smaller particles of dust. In particular it has been found that small tip (dirt outlet) diameters on cyclones can increase separation efficiency. However, it has also been found that as the cyclones decrease in size there is an increased risk of them blocking, which would impact on the overall separation efficiency of the surface treating appliance.

[0005] By way of background, US251380 discloses an industrial centrifugal separator for separating aerosols from gaseous media and includes a scraper mechanism to unclog the cyclone. Also, EP0476169 discloses another industrial-use cyclone system which separates powder from an airflow removed from a powder-coating booth. The cyclones in the system are cleaned by an air-jet mechanism. Both arrangements are large in scale and complex, and so are unsuitable for application to a domestic vacuum cleaner.

[0006] Against this background, the invention provides a surface treating appliance or cyclonic separating apparatus comprising a plurality of frusto-conical cyclones arranged in parallel and each having a relatively wide, rigid frusto-conical portion and a relatively narrow, flexible frusto-conical portion connected to the relatively wide portion. The relatively wide portion comprising at least one dirty air inlet and the relatively narrow portion comprising a dirt outlet, wherein the flexible portion of each cyclone is arranged to vibrate as airflow moves through

the cyclone during use.

[0007] The dirty air inlet may be formed as an integral inlet portion of the cyclone.

[0008] Forming the at least one dirty air inlet in a rigid portion of the cyclone can enable the size of the at least one dirty inlet to be maintained in a stationary position during use of the cyclone, and can enable the size of the at least one dirty air inlet to be maintained constant during use of the cyclone.

[0009] The cyclone may be a reverse flow cyclone.

[0010] As used herein the term "flexible" shall be taken to mean that the portion of the at least one cyclone which is flexible will be deflected more than 1mm when subjected to the test conditions described in Test 1 or Test 2 in the specific description and shown in Figures 13a to 13c. As an example, the flexible portion may have a Shore A value of up to 80 Shore A, for example the flexible portion may have a Shore A value of from 20 or 25 or 30 or 35 to 40 or 45 or 50 or 55 or 60. The entire cyclone or a flexible portion of the cyclone may be formed from an elastomer, for example a plastics material, or rubber. The entire cyclone or a flexible portion of the cyclone may be formed, for example, from a thermoplastic elastomer, TPU, silicone rubber or natural rubber.

[0011] As used herein the term "rigid" shall be taken to mean that the portion of the at least one cyclone which is rigid will be deflected less than 1mm when subjected to the test conditions described in Test 1 or Test 2 in the specific description and as shown in Figures 13a to 13c. As an example, the rigid portion may have a Shore D value of above 60 Shore D, for example the rigid portion may have a Shore D value of from 60 or 65 or 70 to 75 or 80 or 85 or 90. The rigid portion may be formed from a plastics or metal material, for example poly propylene, ABS rubber or aluminium.

[0012] As used herein the term "tip" shall be taken to mean an end portion of the at least one cyclone. In a preferred embodiment the tip may be a lower end portion of the at least one cyclone. The tip may comprise up to 95% of the total length of the cyclone but more preferably the tip may be 50% or less than the total length of the at least one cyclone. For example the tip may be from 5 or 10 or 15 or 20 to 25 or 30 or 35 or 40% of the total length of the at least one cyclone. In a preferred embodiment the tip may have a wall thickness of from 0.2 or 0.5 to 1 or 1.5mm. Part of the flexible portion of the at least one cyclone may comprise the tip. Alternatively, the tip may form the flexible portion of the at least one cyclone.

[0013] In a particular embodiment where the cyclone comprises a rigid portion and a flexible portion, the flexible portion may be over-moulded on to the rigid portion of the at least one cyclone. Additionally or alternatively, the flexible portion may be glued, fixed or clamped to the rigid portion by any suitable method or by using any suitable fixing means. The flexible portion is preferably attached to the rigid portion in an airtight manner. The flexible portion may be fixed to the rigid portion such that there is a step, either internal or external, between the

flexible portion and the rigid portion. Preferably the inner surface of the at least one cyclone is smooth or otherwise such that there is no step between the rigid portion and the flexible portion.

[0014] The at least one cyclone may be from 5mm to 400mm in length, for example the at least one cyclone may be from 10 or 20 or 30 or 40 or 50 or 60 or 70 to 100 or 200 or 300 or 400 mm in length. The dirt outlet may have a diameter of from 0.2 to 20mm, for example the dirt outlet may have a diameter of from 0.2 or 0.4 or 0.5 or 0.6 or 0.8 to 1 or 1.5 or 2 or 5 or 10mm. The dirt outlet may be chamfered. In an embodiment where the dirt outlet is chamfered, the dirt outlet diameter may be measured as the diameter at the uppermost point of the dirt outlet.

[0015] At least a portion of the at least one cyclone is arranged to vibrate as airflow moves through the surface treating apparatus during use. Constructing a flexible portion from a material having a Shore A value of from 20 to 60 has been found to result in a flexible portion which vibrates as airflow moves through the surface treating apparatus during use. In particular the dirt outlet in the flexible portion has been found to vibrate.

[0016] In a particularly preferred embodiment where a flexible tip was formed using material having a Shore A hardness of 20 and having a dirt outlet diameter of 0.5mm, the flexible tips were found to vibrate at around 500Hz, at an amplitude of approx 0.05mm. This had the effect of breaking off dust deposits before they could load up and block the flexible tip of the cyclone. This frequency and amplitude of vibration was achieved by the airflow through the cyclone exciting the dirt outlet at its natural frequency. Thus using such a cyclone advantageously may mean that smaller cyclones, that previously would have been liable to blockage, may now be used. Being able to utilise smaller cyclones may therefore also advantageously increase the overall separation efficiency of the surface treating appliance.

[0017] The surface treating apparatus may further comprise means for dilating, inflating, deforming, compressing and/or moving a flexible portion of the at least one cyclone.

[0018] The flexible portion of the at least one cyclone, for example the flexible tip, may be dilatable such that it can be dilated and/or relaxed in order to change its shape and/or dimensions. The flexible portion may be arranged such that in its relaxed state the dirt outlet has a smaller diameter than when it is in its dilated state. In this way during use of the surface treating appliance, the flexible portion is relaxed such that it has a small diameter dirt outlet, thus increasing the separation efficiency of the cyclone. Then, after use, the flexible portion can be dilated to increase the diameter of the dirt outlet to help dislodge any dirt which may have built up in the flexible portion during use.

[0019] The flexible portion of the at least one cyclone, for example the flexible tip, may be inflatable such that it can be partially or totally filled with a fluid in order to

change its shape and/or dimensions. The flexible portion may be arranged such that in its inflated state the dirt outlet has a smaller diameter than when it is in its deflated state. In this way, during use of the surface treating appliance, the flexible portion can be inflated such that it has a small diameter dirt outlet, thus increasing the separation efficiency of the cyclone. Then, after use, the flexible portion can be deflated to increase the diameter of the dirt outlet to help dislodge any dirt which may have built up in the flexible portion during use.

[0020] Additionally or alternatively, the cyclonic separating apparatus may further comprise a device for manually, or mechanically, moving or compressing a flexible portion of the cyclone. For example, the device may comprise a paddle, pad, arm or rod which may be arranged to hit against, compress or move a flexible portion of the cyclone, for example the flexible tip, in order to try to help dislodge any dirt which may have become trapped in the flexible portion during use of the surface treating appliance. The surface treating appliance comprises a plurality of cyclones, wherein at least a portion of each of the cyclones is flexible. The plurality of cyclones are arranged in parallel in terms of airflow through the cyclones.

[0021] The plurality of cyclones may also be arranged such that they are physically in parallel with each other. For example, the cyclones may be arranged about an axis, with the cyclones being equally spaced from the axis and, preferably equally spaced about, the axis.

[0022] Alternatively, one or more cyclones may be arranged as a stack, either in single rows or in groups. For example, the plurality of cyclones may comprise a first set of cyclones arranged in a first arrangement about the axis, and a second set of cyclones arranged in a second arrangement about the axis and spaced along the axis from the first set.

[0023] The surface treating appliance may further comprise one or more rigid cyclones arranged either upstream or downstream of the cyclone(s). The rigid cyclone(s) may be arranged in parallel or in series in terms of airflow through the rigid cyclone(s).

[0024] In a particular embodiment the plurality of cyclones may form at least a part of a filter cartridge which may be removable from the remainder of the surface treating appliance. This may advantageously allow the filter cartridge to be more easily cleaned and/or replaced if desired.

[0025] The plurality of cyclones may be orientated such that their longitudinal axes are vertical or substantially vertical. In a preferred embodiment their longitudinal axes may be substantially parallel or parallel, and preferably parallel to said axis about which the cyclones are arranged.

[0026] In an alternative embodiment, the cyclones may be arranged in an annular arrangement with their dirt outlets pointing substantially inwardly. The cyclones may be orientated such that their longitudinal axes are horizontal or substantially horizontal. Alternatively the cyclones may be orientated such that their longitudinal axes

are inclined to said axis about which the cyclones are arranged.

[0027] In embodiments where there is a rigid portion and a flexible tip or portion, one or more of the flexible tips or portions may be bent, curved or shaped away from the longitudinal axis of the rigid portion.

[0028] Two or more layers or sets of cyclones may be stacked to form a column of cyclones arranged with a parallel airflow path through each of the cyclones.

[0029] The cyclones preferably form part of a cyclonic separating apparatus comprising a first cyclonic cleaning stage, and a second cyclonic cleaning stage located downstream from the first cyclonic cleaning stage and comprising the plurality of cyclones.

[0030] The term "surface treating appliance" is intended to have a broad meaning, and includes a wide range of machines having a head for travelling over a surface to clean or treat the surface in some manner. It includes, inter alia, machines which apply suction to the surface so as to draw material from it, such as vacuum cleaners (dry, wet and wet/dry), as well as machines which apply material to the surface, such as polishing/waxing machines, pressure washing machines, ground marking machines and shampooing machines. It also includes lawn mowers and other cutting machines. In a preferred embodiment the surface treating appliance is a vacuum cleaner.

[0031] Features described above in connection with the first aspect of the invention are equally applicable to each of the second and third aspects of the invention, and vice versa.

[0032] The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of an upright vacuum cleaner,

Figure 2 shows a perspective view of cyclonic separating apparatus of the vacuum cleaner shown in Figure 1;

Figure 3 shows a section through a first embodiment of a cyclonic separating apparatus, where a cyclone is made entirely from a flexible material, the cyclone not forming part of the present invention;

Figure 4a shows a section through a second embodiment of a cyclonic separating apparatus, where a cyclone has a rigid portion and a flexible tip; and Figure 4b shows schematic views of the flexible tips in (1) rotation, (2) compression and (3) side to side movement;

Figure 5a shows a close-up section through a cyclone of a third embodiment of a cyclonic separating apparatus, the cyclone having a rigid portion and a dilatable flexible tip, the flexible tip being shown in

its relaxed state; and Figure 5b shows the cyclone shown in Figure 5a where the flexible tip is in its dilated state;

Figures 6a to 6d show sections through a fourth embodiment of a cyclonic separating apparatus, showing a one-way ball valve for controlling dilation of the flexible tips of the cyclones, the flexible tips being shown in their relaxed state; and Figure 6e shows a section through this cyclonic separating apparatus showing the flexible tips in their dilated state;

Figure 7a shows a section through a fifth embodiment of a cyclonic separating apparatus, showing a control valve for controlling dilation of the flexible portion of the cyclones, the flexible tips being shown in their relaxed state; and Figure 7b shows a section through this cyclonic separating apparatus showing the flexible tips in their dilated state;

Figure 8 shows a section through a sixth embodiment of a cyclonic separating apparatus with an electro mechanical pump for controlling dilation of the flexible portion of the cyclones, the flexible tips being shown in their dilated state;

Figure 9a shows a section through a seventh embodiment of a cyclonic separating apparatus with a motorised paddle for flicking the flexible tips of each cyclone; Figure 9b shows an inverted perspective view of the cyclones and paddle of this cyclonic separating apparatus; and Figure 9c shows a perspective view from underneath of a ratchet mechanism for turning the paddles shown in Figure 9b;

Figure 10a shows a section through an eighth embodiment of a cyclonic separating apparatus having a plurality of cyclones arranged in parallel, each cyclone having a flexible portion; Figure 10b shows a close up of the section circled in Figure 10a; and Figure 10c shows a perspective view from above of the cyclones of Figures 10a and 10b in the form of a removable filter cartridge;

Figure 11a shows a perspective view of a ninth embodiment of a cyclonic separating apparatus where the cyclones are arranged in a circle with their dirt outlets pointing substantially inwardly; Figure 11b shows a section through this cyclonic separating apparatus, showing a plurality of layers of cyclones stacked to form a column of cyclones; and Figure 11c shows a section taken along line B-B shown in Figure 11b showing a paddle for knocking the flexible tips;

Figure 12 shows a section through a tenth embodiment of a cyclonic separating apparatus where a plurality of layers of cyclones are stacked to form a col-

umn of cyclones, the cyclones being inclined, and where the flexible tips are shaped away from the longitudinal axis of the rigid portion; and

Figure 13a shows how the flexibility of a portion of a cyclone can be tested using Test 1 with a 2mm diameter stylus with a 1mm radius at the tip, with A and B illustrating alternative stylus shapes; Figure 13b shows the deflection of a flexible tip in Test 1 when a load is applied to a point on the inner surface of the cyclone; and Figure 13c shows how the flexibility of a portion of a cyclone can be tested using Test 2 where a wedge tool is used to apply a load to a tip of the cyclone.

[0033] Like reference numerals refer to like parts throughout the specification.

[0034] Figure 1 illustrates a surface treating appliance, which in this example is a vacuum cleaner 1. The vacuum cleaner 1 comprises a main body 2 and a rolling support structure 4 mounted on the main body 2 for manoeuvring the vacuum cleaner 1 across a surface to be cleaned. A cleaner head 6 is pivotably mounted on the lower end of the rolling support structure 4, and a dirty air inlet 8 is provided on the underside of the cleaner head 6 facing the surface to be cleaned. A separating apparatus 10 is removably provided on the main body 2, and ducting 12 provides communication between the dirty air inlet 8 and the separating apparatus 10. A wand and handle assembly 14 is mounted on the main body 2 behind the separating apparatus 10.

[0035] In use, a motor and fan unit (not shown) which is located inside the rolling support structure 4 draws dust laden air into the vacuum cleaner 1 via either the dirty air inlet 8 or the wand 14. The dust laden air is carried to the separating apparatus 10 via the ducting 12, and the entrained dust particles are separated from the air and retained in the separating apparatus 10. The cleaned air passes through the motor and is then ejected from the vacuum cleaner 1.

[0036] The separating apparatus 10 forming part of the vacuum cleaner 1 is shown generally in Figure 2. The specific overall shape of the separating apparatus 10 can be varied according to the type of vacuum cleaner 1 in which the separating apparatus 10 is to be used. For example, the overall length of the separating apparatus 10 can be increased or decreased with respect to the diameter of the separating apparatus 10.

[0037] The separating apparatus 10 comprises a first cyclonic cleaning stage 16 and a second cyclonic cleaning stage 18. In some embodiments the separating apparatus 10 also comprises a pre-motor filter 20 located longitudinally through the separating apparatus 10.

[0038] The first cyclonic cleaning stage 16 comprises an annular chamber 22 located between the outer wall 24 of the separating apparatus 10, which wall 24 is substantially cylindrical in shape, and a second cylindrical wall 26 which is located radially inwardly of and spaced

from the outer wall 24. The lower end of the first cyclonic cleaning stage 16 is closed by a base 28 which is pivotably attached to the outer wall 24 by means of a pivot 30, and held in a closed position by a catch 32. In the closed position, the base 28 is sealed against the lower ends of the walls 24, 26. Releasing the catch 32 allows the base 28 to pivot away from the outer wall 24 and the second cylindrical wall 26 for emptying of the first cyclonic cleaning stage 16 and the second cyclonic cleaning stage 18.

[0039] The top portion of the annular chamber 22 forms a cylindrical cyclone 34 of the first cyclonic cleaning stage 16, and the lower portion of the annular chamber 22 forms a dust collecting bin 36. The second cyclonic cleaning stage 18 comprises twelve secondary cyclones 38, which are arranged in parallel in terms of airflow through the cyclones 38, and a second dust collecting chamber 40.

[0040] A dust laden air inlet 42 is provided in the outer wall 24. The dust laden air inlet 42 is arranged tangentially to the outer wall 24 so as to ensure that incoming dust laden air is forced to follow a helical path around the annular chamber 22. A fluid outlet from the first cyclonic cleaning stage 20 is provided in the form of a mesh shroud 44. The mesh shroud 44 comprises a cylindrical wall 46 in which a large number of perforations 48 are formed. The only fluid outlet from the first cyclonic cleaning stage 16 is formed by the perforations 48 in the shroud 44.

[0041] Figure 3 illustrates a section through a first embodiment of the cyclonic separating apparatus 10. A passageway 50 is formed downstream of the shroud 44. The passageway 50 communicates with the second cyclonic cleaning stage 18. The passageway 50 may be in the form of an annular chamber which leads to inlets 52 of the secondary cyclones 38, or may be in the form of a plurality of distinct air passageways each of which leads to a separate secondary cyclone 38. These secondary cyclones 38 are an example of cyclones which do not form part of the present invention.

[0042] A third cylindrical wall 54 extends downwardly towards the base 28. The third cylindrical wall 54 is located radially inwardly of, and is spaced from, the second cylindrical wall 26 so as to form the second dust collecting chamber 40. When the base 28 is in the closed position, the third cylindrical wall 54 is sealed against the base 28.

[0043] The secondary cyclones 38 are arranged substantially or totally above the first cyclonic cleaning stage 16. The secondary cyclones 38 are arranged in an annular arrangement which is centred on the axis of the first cyclonic cleaning stage 16. In this embodiment, each secondary cyclone 38 has an axis which is generally parallel to the axis of the first cyclonic cleaning stage.

[0044] Each secondary cyclone 38 is generally frustoconical in shape. The relatively narrow portion of each secondary cyclone 38 comprises a dirt outlet 58 which opens into the top of the second dust collecting chamber 40. In use, dust separated by the secondary cyclones 38 will exit through the dirt outlets 58, and will be collected in the second dust collecting chamber 40. A vortex finder

60 is provided at a relatively wide, upper end of each secondary cyclone 38 to provide an air outlet from the secondary cyclone 38. Where provided, the vortex finders 60 communicate with the pre-motor filter 20. Each vortex finder 60 extends through a generally annular top wall 61 of the secondary cyclone 38.

[0045] In the embodiment shown in Figure 3 the secondary cyclones 38 are made entirely of a flexible material, for example rubber, so that the secondary cyclones 38 are deformable. The flexible material is preferably rubber, which in this embodiment has a Shore A value of 22. During use of the vacuum cleaner 1, the secondary cyclones 38 vibrate as airflow passes through them. This vibration has been found to help prevent a build up of dirt within the secondary cyclones 38. The second dust collecting chamber 40 is ideally separated from atmospheric pressure to prevent the secondary cyclones 38 from collapsing.

[0046] Each secondary cyclone 38 has its secondary cyclone dirty air inlet 52 which may be formed from the same material as the remainder of the secondary cyclones 38. In addition, the vortex finders 60 and the top wall 61 of the secondary cyclones 38 may also be formed from a flexible material.

[0047] Figure 4a illustrates a second embodiment of the cyclonic separating apparatus 10. In this second embodiment, each secondary cyclone 38 has a rigid upper portion 62 and a flexible lower portion, comprising a flexible tip 64. The flexible material from which the flexible tips 64 are formed is preferably rubber with a Shore A value of 20. The rigid material is preferably polypropylene with a Shore D value of 60.

[0048] It has been found that the flexible tips 64 vibrate as airflow passes through the secondary cyclones 38 during use of the vacuum cleaner 1. This vibration has been found to help prevent a build-up of dirt within the secondary cyclones 38. Figure 4b illustrates (1) rotation, (2) compression and (3) side-to-side movements as examples of the types of vibration which have been found to occur in the flexible tips 64 as airflow passes through the secondary cyclones 38.

[0049] As shown in Figure 4a, the flexible tips 64 are preferably less than one third of the total length of the secondary cyclones 38. The secondary cyclones 38 are 65.5mm in length and have a dirt outlet diameter of 3.3mm. The flexible tips 64 are 15mm in length. The flexible tips 64 are over-moulded on to the rigid portions 62 such that the inner surfaces 68 of the secondary cyclones 38 are smooth. In this embodiment, the secondary cyclones 38 are arranged so that the axes of the second cyclones 38 are inclined inwardly relative to, and towards, the longitudinal axis of the first cyclonic cleaning stage 16.

[0050] With reference now to Figures 5 to 9, the vacuum cleaner 1 may also further comprise means for dilating, inflating, deforming, compressing and/or moving the flexible tips 64 of the secondary cyclones 38. Figures 5 to 8 show embodiments where the flexible tips 64 are dilatable or inflatable by different methods. Figures 9

show an embodiment where the vacuum cleaner 1 has a device for contacting, flicking or knocking the flexible tips 64.

[0051] Figures 5a and 5b illustrate a dilatable flexible tip 64. The flexible tip 64 comprises an inner wall 70 and an outer wall 72 which may be integrally formed or joined to form a tip chamber 74 therebetween. Figure 5a shows the flexible tip 64 in its relaxed state, and Figure 5b shows the flexible tip 64 in its dilated state. The flexible tips 64 may move between their relaxed and dilated states in response to pressure changes within the cyclonic separating apparatus 10. The flexible tip 64 is overmoulded onto the rigid portion 62 of the secondary cyclone 38. The dirt outlet 58 is largest when the flexible tip 64 is in its dilated state, as shown in Figure 5b.

[0052] In an alternative embodiment the tip chambers 74 may be inflated and deflated by passing a fluid into and out of the tip chambers 74.

[0053] The preferred mode of operation is that the flexible tips 64 are relaxed so that the dirt outlet 58 is at its smallest diameter during use of the vacuum cleaner 1. When the vacuum cleaner 1 is switched off, the flexible tips 64 dilate to release dirt trapped in the secondary cyclones 38, for example into the second dust collecting chamber 40.

[0054] In the embodiment shown in Figures 6a to 6e, the normal operating conditions of the vacuum cleaner 1, where the flexible tips 64 are in their relaxed state, are shown in Figures 6a to 6d. Airflow through the cyclonic separating apparatus 10 is indicated by the arrows shown in Figures 6a and 6c. Figure 6c shows the airflow from the first cyclonic cleaning stage 16 passing through the shroud 44, along the passageway 50 and into the inlets 52 of the secondary cyclones 38. Figure 6a shows the airflow from the secondary cyclones 38 passing through the pre-motor filter 20 towards the motor and fan assembly. The off-condition of the vacuum cleaner 1, where the flexible tips 64 are in their dilated position, is shown in Figure 6e.

[0055] During normal operation of the vacuum cleaner 1 (i.e. in Figures 6a to 6d, the second dust collecting chamber 40 will be at around 9kPa below atmospheric pressure. There will be a similar pressure inside the secondary cyclones 38. In order to prevent the flexible tips 64 from inflating and blocking the dirt outlets 58, the pressure in the tip chambers 74 has to be equalised with the pressure inside the second dust collecting chamber 40 and the pressure inside the secondary cyclones 38. This is achieved by connecting the tip chambers 74 to a similarly low pressure. Thus each tip chamber 74 is fluidly connected to a pressure tap 76 which is located downstream of the pre-motor filter 20.

[0056] Locating the pressure tap 76 downstream of the pre-motor filter 20 is advantageous because the air in this area is clean, and will therefore reduce ingress of dust into the pressure tap 76 and thus into the tip chambers 74. It is also advantageous because the pressure available at the eye of the motor can achieve a maximum

pressure difference to atmosphere, and give the largest dilation of the flexible tips 64. Certainly the pressure at this point is always lower than the pressure inside the second dust collecting chamber 40, and so inflation of the flexible tips 64 will not occur.

[0057] During normal operation of the vacuum cleaner 1 the pressure at the pressure tap 76 is normally around 1.5kPa (which is equal to the pressure drop across the pre-motor filter 20). This has the effect of applying a very slight dilation force to the flexible tips 64, but not enough to significantly deform them.

[0058] Each tip chamber 74 is linked to one pressure tap 76 via a one-way ball valve 78 in a large reservoir chamber 80. This reservoir chamber 80 is required to sustain a low pressure difference long enough to dilate the flexible tips 64 at around 10kpa. Thus when the vacuum cleaner 1 is switched off, the pressure in the secondary cyclones 38 and the second dust collecting chamber 40 returns to atmospheric pressure. The tip chambers 74 however remain at below atmospheric pressure because of the one-way ball valve 78. This means that when the vacuum cleaner 1 is switched off, atmospheric pressure pushes the inner wall 70 of the flexible tip 64 towards the outer wall 72 of the flexible tip 64, causing the dirt outlet 58 to dilate as shown in Figure 6e.

[0059] A seat 82 of the ball valve 78 is scored to allow a controlled leak of air back into the reservoir chamber 80 and tip chamber 74 to allow the flexible tips 64 to relax back into their relaxed position within a few seconds. This mechanism allows the flexible tips 64 to dilate and then quickly relax again each time the vacuum cleaner 1 is switched off, thereby helping to keep the secondary cyclones 38 free of trapped dirt.

[0060] In the embodiment shown in Figures 7a and 7b a control valve 84 is located in a pre motor filter housing 86 to allow instantaneous dilation of the flexible tips 64 at any time. The control valve 84 can be operated by any suitable electrical or mechanical means at a prescribed time interval. For example the control valve 84 may be controlled by an air muscle or mechanical means connected to the on/off switch of the vacuum cleaner 1. The normal operating condition of a vacuum cleaner is shown in Figure 7a. During normal operation the control valve 84 is open, and therefore the second dust collecting chamber 40 will be at around 9kPa below atmospheric pressure. There will be a similar pressure inside the secondary cyclones 38 themselves. In order to prevent the flexible tips 64 from inflating and blocking the dirt outlets 58, the pressure in the tip chamber 74 has to be equalised with the pressure inside the second dust collecting chamber 40 and the pressure inside the secondary cyclones 38. Again this is achieved by connecting the tip chambers 74 to a similarly low pressure. Thus the tip chambers 74 are fluidly connected to a pressure tap 76 which is located downstream of the pre motor filter 20.

[0061] During normal operation of the vacuum cleaner 1, the pressure difference between the second dust collecting chamber 40 and the pressure tap 76 is normally

around 1.5kPa, (which is equal to the pressure drop across the pre-motor filter 20). This has the effect of applying a very slight dilation force to the flexible tips 64, but not enough to significantly deform them. Thus whilst the vacuum cleaner 1 is in operation and the control valve 84 is open, the flexible tips 64 will be in the relaxed position.

[0062] When desired, for example when the vacuum cleaner 1 is switched off, the control valve 84 can be closed as shown in Figure 7b. Closing the control valve 84 restricts the airflow through the secondary cyclones 38 and creates a large pressure drop inside the tip chambers 74 which will remain below atmospheric pressure whilst the second dust collecting chamber 40 and the secondary cyclones 38 return to atmospheric pressure. This causes the flexible tips 64 to dilate into the position shown in Figure 7b. Once the flexible tips 64 have been dilated to help clear any trapped dirt, the control valve 84 can be returned to the open position shown in Figure 7a so that the flexible tips 64 return to their relaxed state.

[0063] In the embodiment shown in Figure 8 a controlled electro-mechanical pump 88 is arranged to remove the air around the flexible tip 64 to draw open the flexible tips 64 into the dilated position. The electro-mechanical pump 88 can be controlled at any specific time interval, or its action could be related to the removal of the cyclonic separating apparatus 10 from the main body 2 of the vacuum cleaner 1. Alternatively control of the electro-mechanical pump 88 could be related to the switching on or switching off of the vacuum cleaner 1.

[0064] In the embodiment shown in Figures 9a to 9c the secondary cyclones 38 have a rigid upper portion 62 and a flexible tip 64. In addition, the vacuum cleaner 1 comprises a plurality of paddles 92 which are arranged such that they can strike, flick or wipe the flexible tips 64. A large mechanical movement may be used to draw the flexible tips 64 relatively slowly to one side. As the paddles 92 move beyond the flexible tips 64, the flexible tips 64 will be released. Due to the material properties of the flexible tips 64 this action helps to accelerate the movement of the flexible tips 64 and allows them to flick back to the resting position with a series of fast vibrating oscillations. During this action, any dirt caught in the flexible tips 64 may be disrupted, dislodged from the inner surfaces 68 of the secondary cyclones 38 and drop into the second dust collecting chamber 40. Figure 9a shows an electric motor 90 which is arranged to move the paddles 92 relative to the secondary cyclones 38. In this embodiment the paddles 92 are arranged to move in a circle such that they flick the flexible tip 64 of each of the secondary cyclones 38 in turn. In Figure 9c a ratchet device 94 for turning the paddles 92 relative to the secondary cyclones 38 is shown. Such a ratchet device 94 may be connected to an air muscle, or alternatively operated on removal or replacement of the cyclonic separating apparatus 10 on the main body 2 of the vacuum cleaner 1.

[0065] Alternative constructions of cyclonic separating apparatus 10 and cyclones 96 according to the present

invention are shown in Figures 10 to 12. In each of these embodiments each of a plurality of cyclones 96 has a rigid portion 62 and a flexible tip 64.

[0066] Figures 10a and 10b illustrate a plurality of cyclones 96 arranged in parallel in terms of airflow through the cyclones 96. The plurality of cyclones 96 are also arranged such that they are physically in parallel with each other. In this embodiment the plurality of cyclones 96 form the filter cartridge 98, shown in Figure 10c, which may be removable from the remainder of the vacuum cleaner 1 for cleaning or replacement if desired. In Figure 10a and 10b the plurality of cyclones 96 are orientated such that their longitudinal axes are parallel with each other.

[0067] In an alternative embodiment shown in Figures 11a to 11c, the cyclones 96 are arranged in an annular arrangement with their dirt outlets 58 pointing substantially inwardly. The cyclones 96 are orientated such that their longitudinal axes are horizontal or substantially horizontal. In this embodiment the cyclones 96 form a filter cartridge 98, which may be removable from the remainder of the vacuum cleaner 1 for cleaning or replacement.

[0068] In Figure 12 the cyclones 96 are orientated such that their longitudinal axes are inclined and the flexible tips 64 are shaped away from the longitudinal axis of the rigid portion 62.

[0069] In the embodiments shown in Figures 11 and 12, an annular arrangement of cyclones comprises a plurality of layers or sets of cyclones 96 that are stacked to form a column of cyclones 96 arranged with a parallel airflow path through each of the cyclones 96. In Figure 12, the sets of cyclones are spaced along the axis of the first cyclonic cleaning stage 16. In these embodiments, the vacuum cleaner 1 comprises a moving means for knocking and/or brushing the flexible tips 64. In Figure 11 the moving means is a paddle 92 which is arranged to sweep about a circular path to engage and release sequentially the flexible tips 64. In Figure 12 the moving means is a rod 100 which has a plurality of projections 102 arranged around and along its length. This rod 100 is arranged such that it can move relative to the flexible tips 64. In the embodiment shown the rod 100 is arranged to move up and down such that each projection 102 flicks a flexible tip 64 in order to help remove any dust located in the flexible tip 64. If desired air muscle activation could be used to drive movement of the rod 100. In this embodiment, the cyclones 96 are arranged as a third stage of cyclonic separation 104. These cyclones are therefore arranged downstream of the secondary cyclones 38 in place of the pre motor filter.

[0070] In order to determine whether a portion of a cyclone is "flexible" or "rigid", one or both of the following tests may be performed.

Test 1

[0071] The flexibility of a portion of the cyclone can be tested using a 2mm diameter stylus with a 1mm radius

at the tip. The stylus can be shaped as A or B, as shown in Figure 13a. The stylus is used to apply a Load L1 of 20N to a point on the inner surface of the cyclone. The deflection X of the cyclone surface is then ascertained.

5 The shape distortion can be as C or D in Figure 13b at any point on the inner surface of the cyclone. A deflection X of at least 1mm is taken to mean that the portion of the cyclone being tested is flexible. A deflection of less than 1mm is taken to mean that the portion of the cyclone being tested is rigid.

Test 2

[0072] A wedge tool as shown at E in Figure 13c is used to apply a load L2 of 50N. The elongation of the cyclone is measured. A deflection X of at least 1mm is taken to mean that the portion of the cyclone being tested is flexible. A deflection of less than 1mm is taken to mean that the portion of the cyclone being tested is rigid.

Claims

1. A surface treating appliance (1) comprising a plurality of frusto-conical cyclones (38;96) arranged in parallel and each having a relatively wide, rigid frusto-conical portion (62) and a relatively narrow, flexible frusto-conical portion (64) connected to the relatively wide portion; the relatively wide portion comprising at least one dirty air inlet (52), and the relatively narrow portion comprising a dirt outlet (58); wherein the flexible portion (64) of each cyclone is arranged to vibrate as airflow moves through the cyclone during use.
2. The surface treating appliance according to claim 1, wherein the flexible portion has a Shore A value of up to 60 Shore A.
3. The surface treating appliance according to claim 1 or claim 2, wherein the rigid portion has a Shore D value of above 60 Shore D.
4. The surface treating appliance according to any preceding claim, comprising means for moving the flexible portion of each cyclone.
5. The surface treating appliance according to claim 4, wherein the moving means is arranged to move the flexible portion of each cyclone by one of dilation, inflation, deformation and compression of the flexible portion.
6. The surface treating appliance according to any preceding claim, wherein the plurality of cyclones form at least a part of a filter cartridge (98) which may be removable from the remainder of the surface treating appliance.

7. The surface treating appliance according to any preceding claim, wherein the cyclones are arranged about an axis.
8. The surface treating appliance according to claim 7, wherein the cyclones are oriented such that their longitudinal axes are substantially parallel to said axis. 5
9. The surface treating appliance according to claim 7, wherein the cyclones are oriented such that their longitudinal axes extend towards said axis. 10
10. The surface treating appliance according to any of claims 7 to 9, wherein the plurality of cyclones is divided into at least a first set of cyclones and a second set of cyclones, the first set of cyclones being spaced along said axis from the second set of cyclones. 15
11. The surface treating appliance according to any preceding claim, comprising a cyclonic separating apparatus comprising a first cyclonic cleaning stage (16), and a second cyclonic cleaning stage (18) located downstream from the first cyclonic cleaning stage and comprising the plurality of cyclones (38;96). 20 25
12. The surface treating appliance according to any preceding claim, wherein the flexible portion (64) of each cyclone is connected to the rigid portion (62) of that cyclone so that the internal interface between the flexible portion and the rigid portion is smooth. 30
13. The surface treating application according to any preceding claim, wherein the flexible portion of each cyclone is over-moulded on to the rigid portion of that cyclone. 35
14. The surface treating appliance according to any preceding claim further comprising one or more rigid cyclones. 40
15. The surface treating appliance according to any preceding claim in the form of a vacuum cleaner. 45

Patentansprüche

1. Vorrichtung zur Oberflächenbehandlung (1), umfassend mehrere kegelstumpfförmige Zykclone (38; 96), die parallel angeordnet sind und jeweils einen relativ breiten, starren kegelstumpfförmigen Teil (62) und einen mit dem relativ breiten Teil verbundenen relativ schmalen, flexiblen kegelstumpfförmigen Teil (64) haben; wobei der relativ breite Teil wenigstens einen Schmutzlufteinlass (52) aufweist und der relativ schmale Teil einen Schmutzauslass (58) aufweist; wobei der flexible Teil (64) jedes Zyklons angeordnet 50 55

ist, um während des Gebrauchs bei der Bewegung des Luftstroms durch den Zyklon zu vibrieren.

2. Vorrichtung zur Oberflächenbehandlung nach Anspruch 1, wobei der flexible Teil eine Shore-A-Härte bis 60 Shore A hat.
3. Vorrichtung zur Oberflächenbehandlung nach Anspruch 1 oder Anspruch 2, wobei der starre Teil eine Shore-D-Härte über 60 Shore D hat.
4. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche, die ein Mittel zum Bewegen des flexiblen Teils jedes Zyklons aufweist.
5. Vorrichtung zur Oberflächenbehandlung nach Anspruch 4, wobei das Bewegungsmittel angeordnet ist, um den flexiblen Teil jedes Zyklons durch eines von Erweiterung, Aufblähung, Verformung und Zusammendrücken des flexiblen Teils zu bewegen.
6. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche, wobei die mehreren Zykclone zumindest Teil eines Filtereinsatzes (98) bilden, der von der übrigen Oberflächenbehandlungsvorrichtung abnehmbar ist.
7. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche, wobei die Zykclone um eine Achse angeordnet sind.
8. Vorrichtung zur Oberflächenbehandlung nach Anspruch 7, wobei die Zykclone so ausgerichtet sind, dass ihre Längsachsen zur genannten Achse im Wesentlichen parallel sind.
9. Vorrichtung zur Oberflächenbehandlung nach Anspruch 7, wobei die Zykclone so ausgerichtet sind, dass ihre Längsachsen zur genannten Achse verlaufen.
10. Vorrichtung zur Oberflächenbehandlung nach einem der Ansprüche 7 bis 9, wobei die mehreren Zykclone in wenigstens einen ersten Zykklonsatz und einen zweiten Zykklonsatz unterteilt sind, wobei der erste Zykklonsatz an der genannten Achse entlang von dem zweiten Zykklonsatz beabstandet ist.
11. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche, die eine Zykcloneabscheidevorrichtung aufweist, die eine erste Zykclonereinigungsstufe (16) und eine zweite Zykclonereinigungsstufe (18) aufweist, die sich stromabwärts von der ersten Zykclonereinigungsstufe befindet und die mehreren Zykclone (38; 96) aufweist.
12. Vorrichtung zur Oberflächenbehandlung nach ei-

nem der vorhergehenden Ansprüche, wobei der flexible Teil (64) jedes Zyklons mit dem starren Teil (62) dieses Zyklons verbunden ist, sodass der innere Übergang zwischen dem flexiblen Teil und dem starren Teil glatt ist.

13. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche, wobei der flexible Teil jedes Zyklons durch Umspritzen auf den starren Teil dieses Zyklons aufgespritzt ist.
14. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche, die ferner einen oder mehr starre Zykclone aufweist.
15. Vorrichtung zur Oberflächenbehandlung nach einem der vorhergehenden Ansprüche in der Form eines Staubsaugers.

Revendications

1. Appareil de traitement de surface (1), comprenant une pluralité de cyclones tronconiques (38 ; 96) disposés en parallèle et ayant chacun une partie tronconique rigide relativement large (62) et une partie tronconique flexible relativement étroite (64) reliée à la partie relativement large ; la partie relativement large comprenant au moins une entrée d'air souillé (52), et la partie relativement étroite comprenant une sortie de saleté (58) ; dans lequel la partie flexible (64) de chaque cyclone peut vibrer lorsque le débit d'air s'écoule dans le cyclone en fonctionnement.
2. Appareil de traitement de surface selon la revendication 1, dans lequel la partie flexible a une valeur Shore A inférieure à 60 Shore A.
3. Appareil de traitement de surface selon la revendication 1 ou 2, dans lequel la partie rigide a une valeur Shore D supérieure à 60 Shore D.
4. Appareil de traitement de surface selon l'une des revendications précédentes, comprenant un dispositif de déplacement de la partie flexible de chaque cyclone.
5. Appareil de traitement de surface selon la revendication 4, dans lequel le dispositif de déplacement peut déplacer la partie flexible de chaque cyclone par dilatation, inflation, déformation ou compression de la partie flexible.
6. Appareil de traitement de surface selon l'une des revendications précédentes, dans lequel la pluralité de cyclones forme au moins une partie d'une cartouche filtrante (98) qui peut être amovible du reste de l'appareil de traitement de surface.

7. Appareil de traitement de surface selon l'une des revendications précédentes, dans lequel les cyclones sont disposés autour d'un axe.
8. Appareil de traitement de surface selon la revendication 7, dans lequel les cyclones sont orientés de telle sorte que leurs axes longitudinaux sont essentiellement parallèles audit axe.
9. Appareil de traitement de surface selon la revendication 7, dans lequel les cyclones sont orientés de telle sorte que leurs axes longitudinaux s'étendent en direction dudit axe.
10. Appareil de traitement de surface selon l'une quelconque des revendications 7 à 9, dans lequel la pluralité de cyclones est divisée entre au moins un premier jeu de cyclones et un deuxième jeu de cyclones, le premier jeu de cyclones étant espacé du deuxième jeu de cyclones le long dudit axe.
11. Appareil de traitement de surface selon l'une des revendications précédentes, comprenant un appareil de séparation cyclonique comprenant un premier palier de nettoyage cyclonique (16) et un deuxième palier de nettoyage cyclonique (18) se trouvant en aval du premier palier de nettoyage cyclonique et comprenant la pluralité de cyclones (38 ; 96).
12. Appareil de traitement de surface selon l'une des revendications précédentes, dans lequel la partie flexible (64) de chaque cyclone est reliée à la partie rigide (62) de ce cyclone de telle sorte que l'interface interne entre la partie flexible et la partie rigide est lisse.
13. Appareil de traitement de surface selon l'une des revendications précédentes, dans lequel la partie flexible de chaque cyclone est surmoulée sur la partie rigide de ce cyclone.
14. Appareil de traitement de surface selon l'une des revendications précédentes, comprenant en outre un ou plusieurs cyclones rigides.
15. Appareil de traitement de surface selon l'une des revendications précédentes, sous la forme d'un aspirateur.

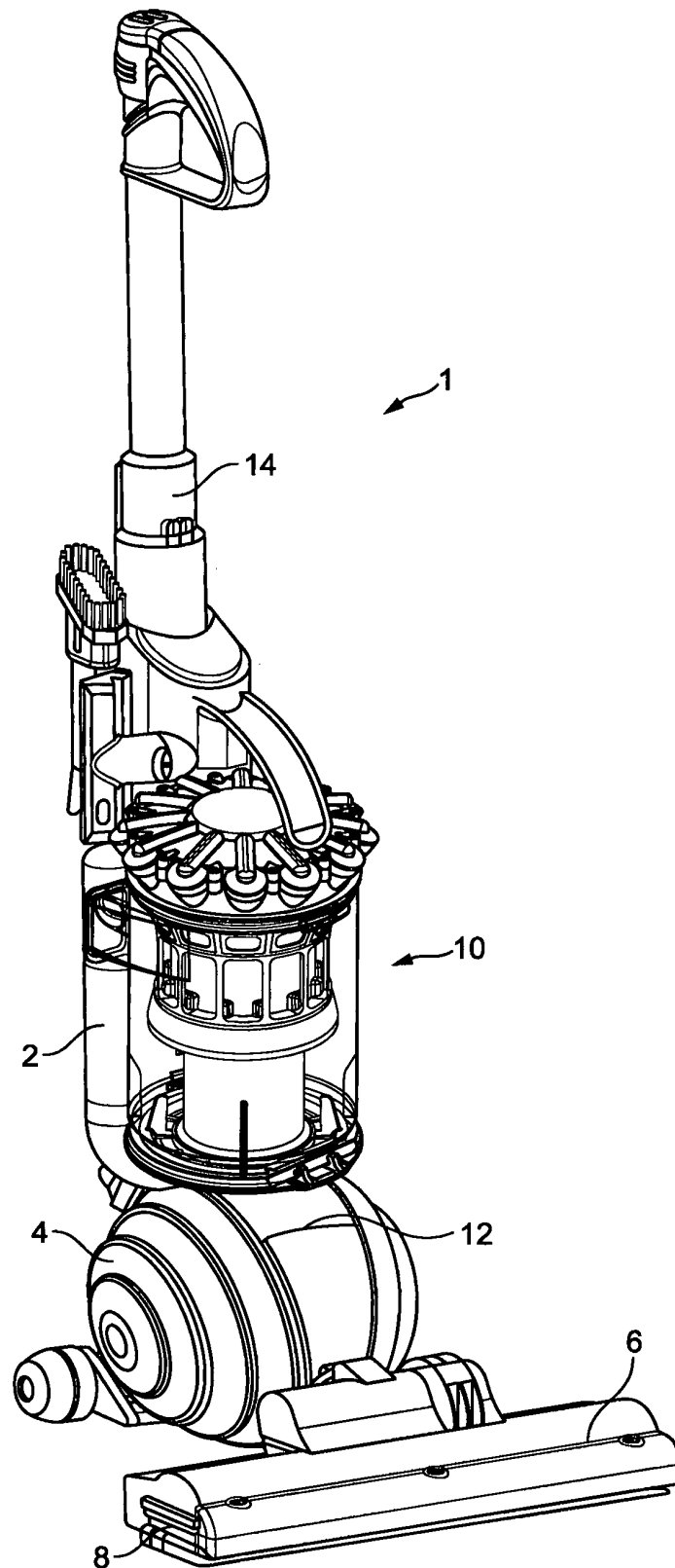


FIG. 1

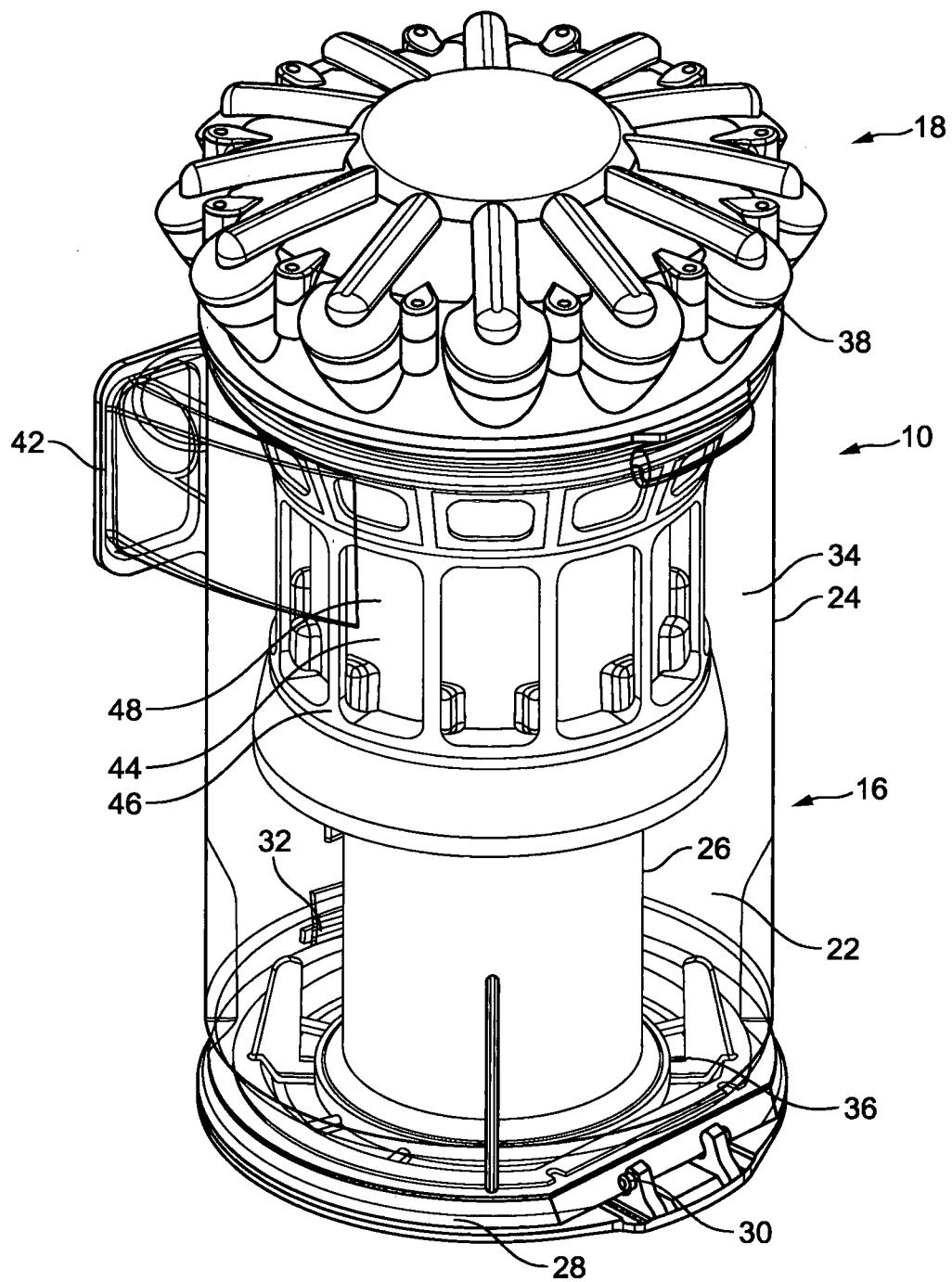


FIG. 2

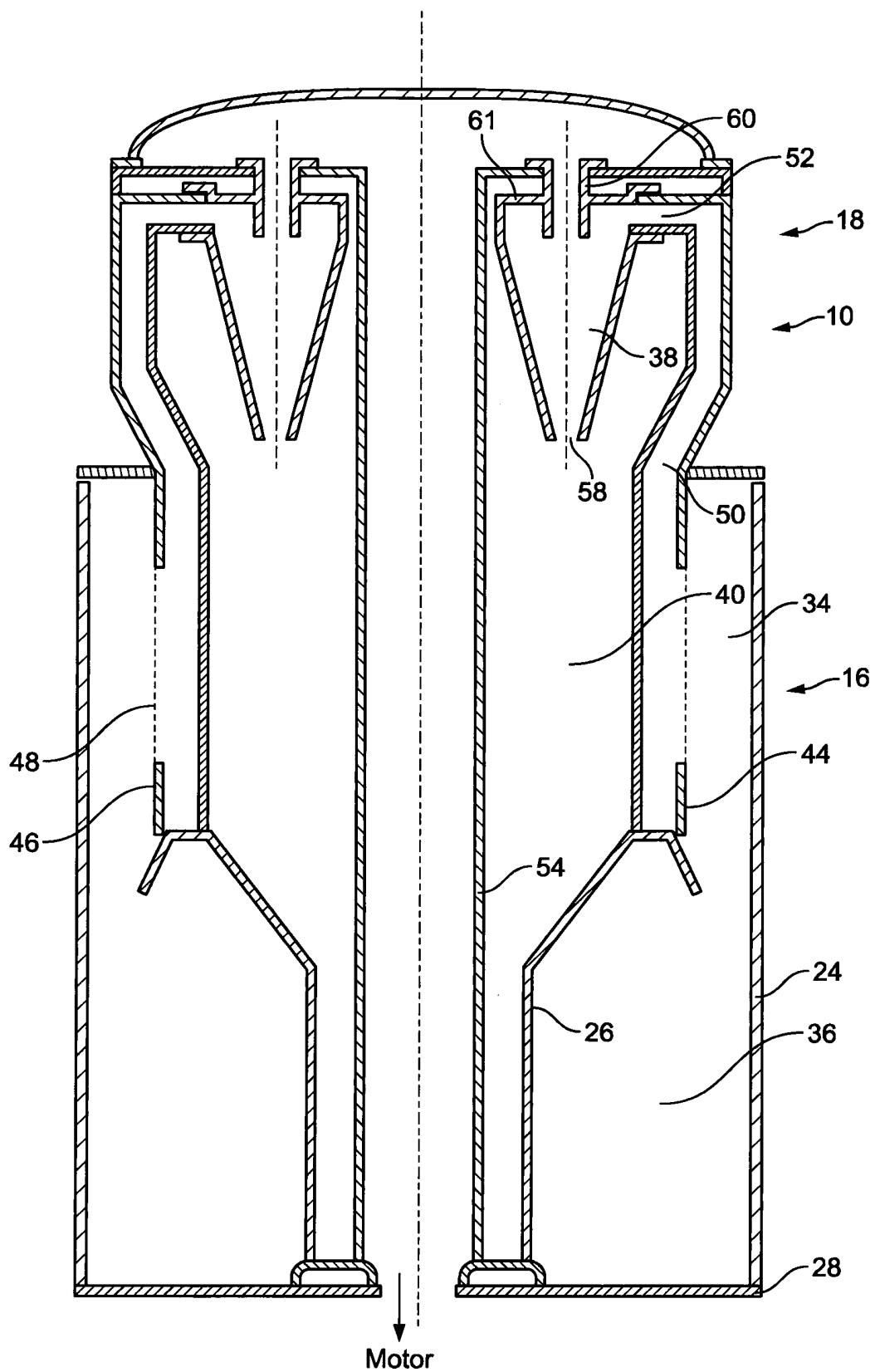


FIG. 3

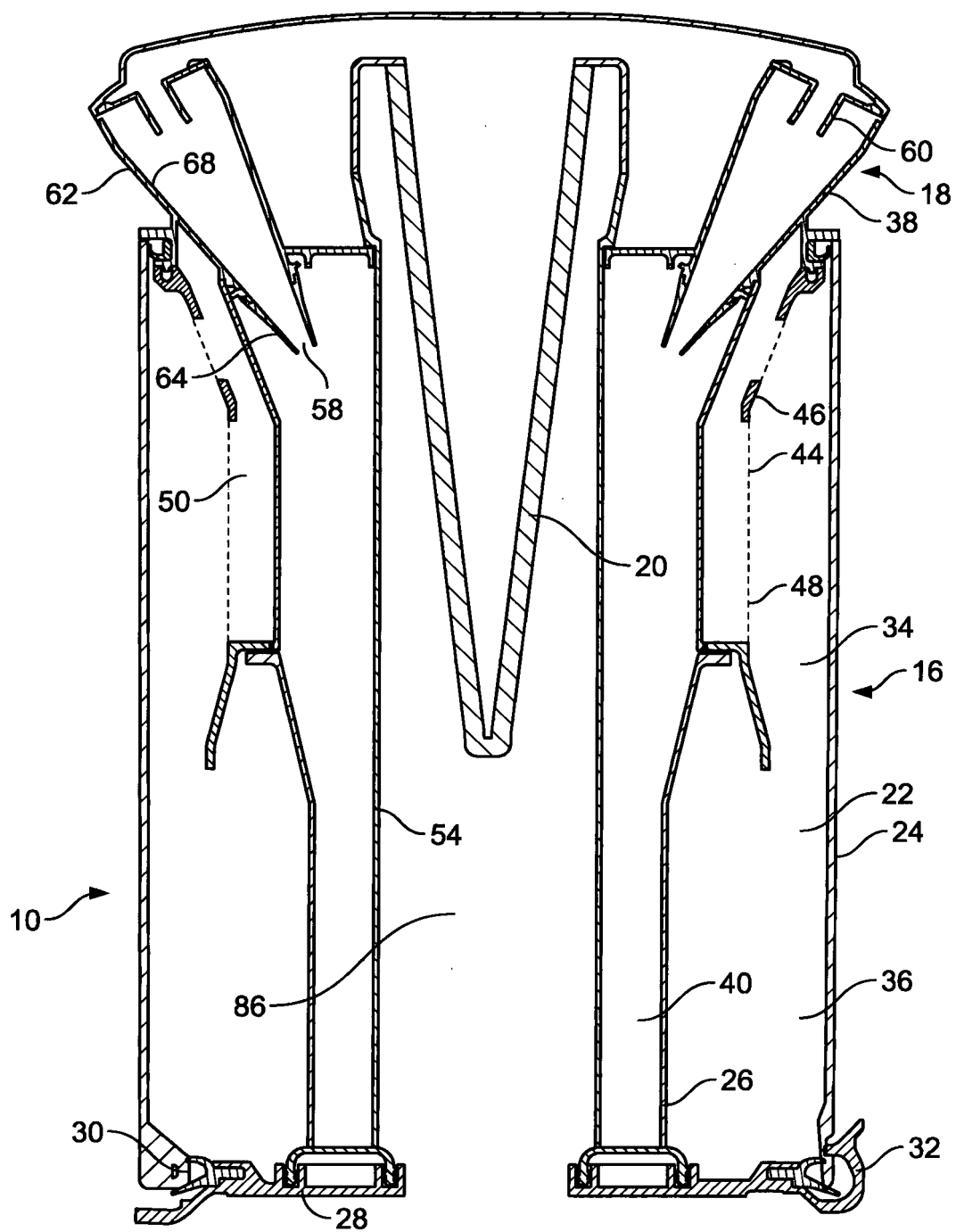


FIG. 4a

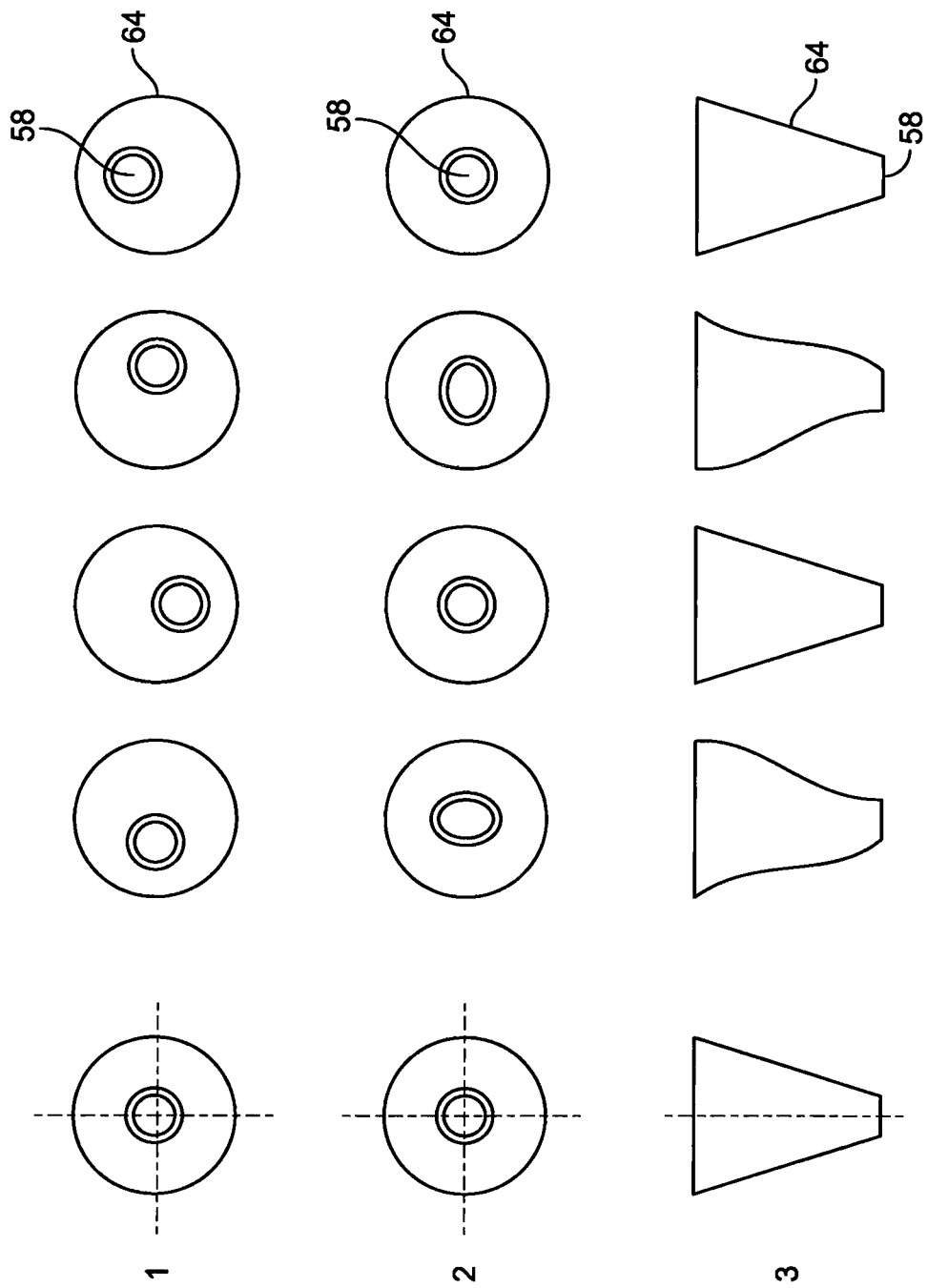


FIG. 4b

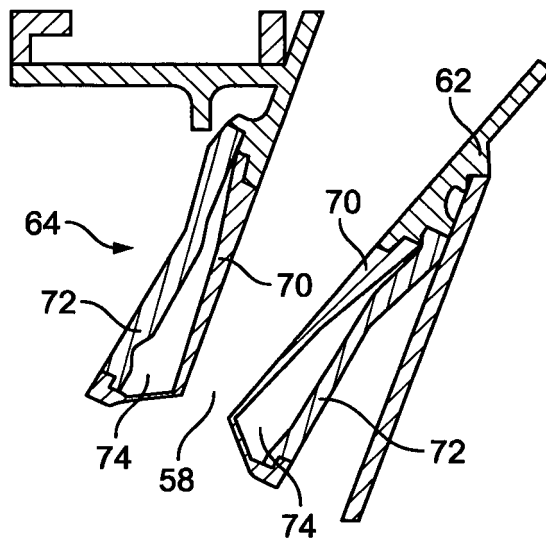


FIG. 5a

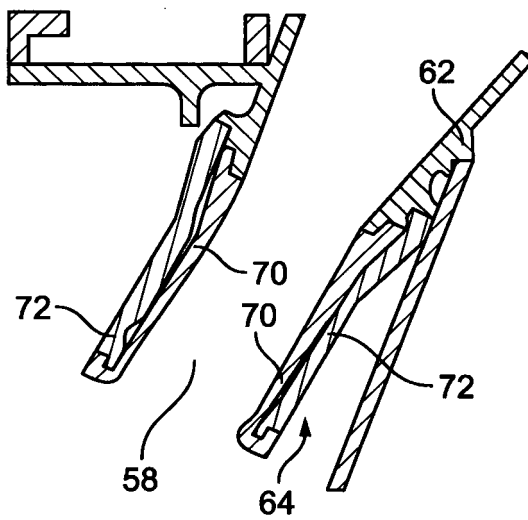


FIG. 5b

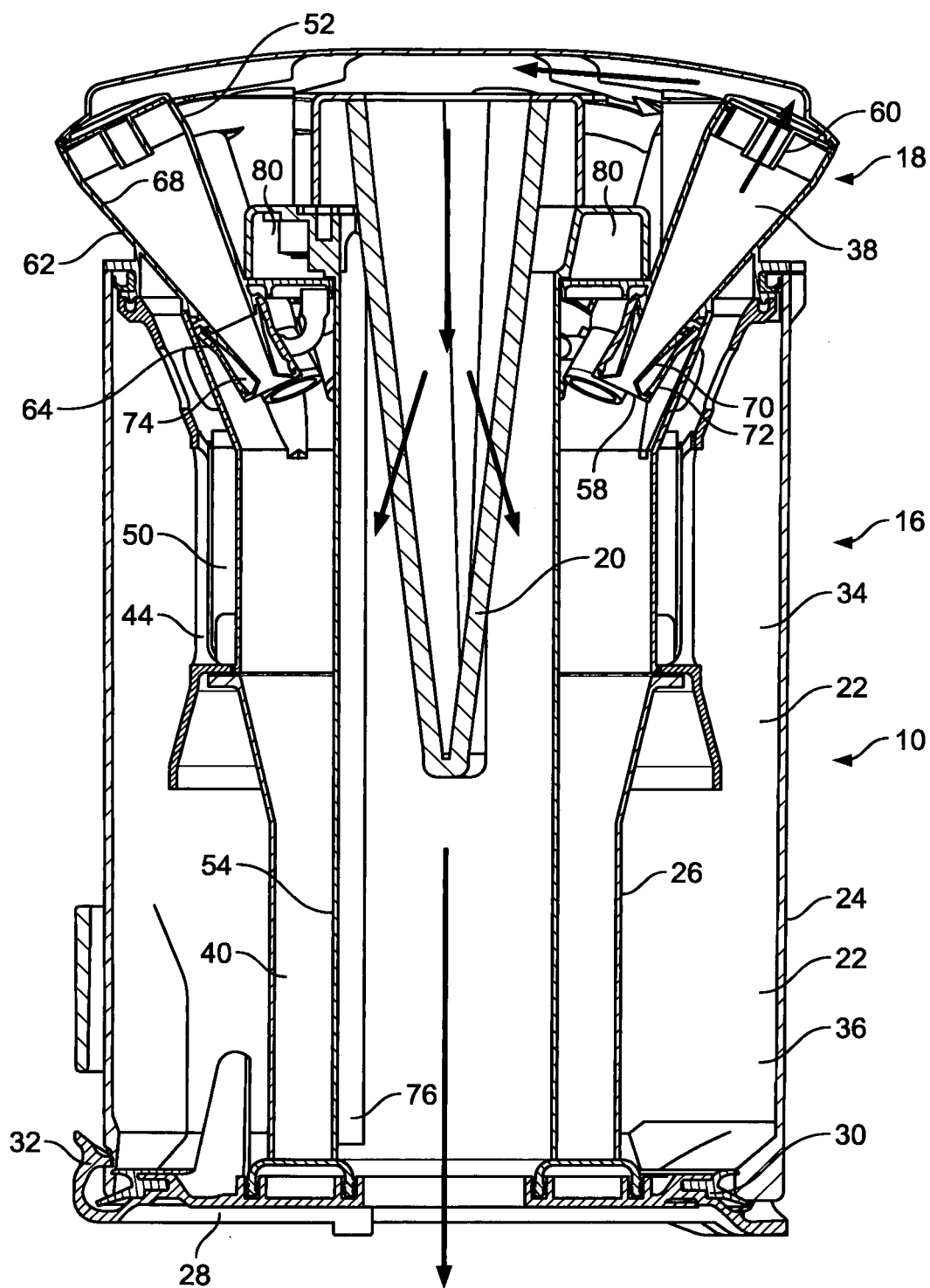


FIG. 6a

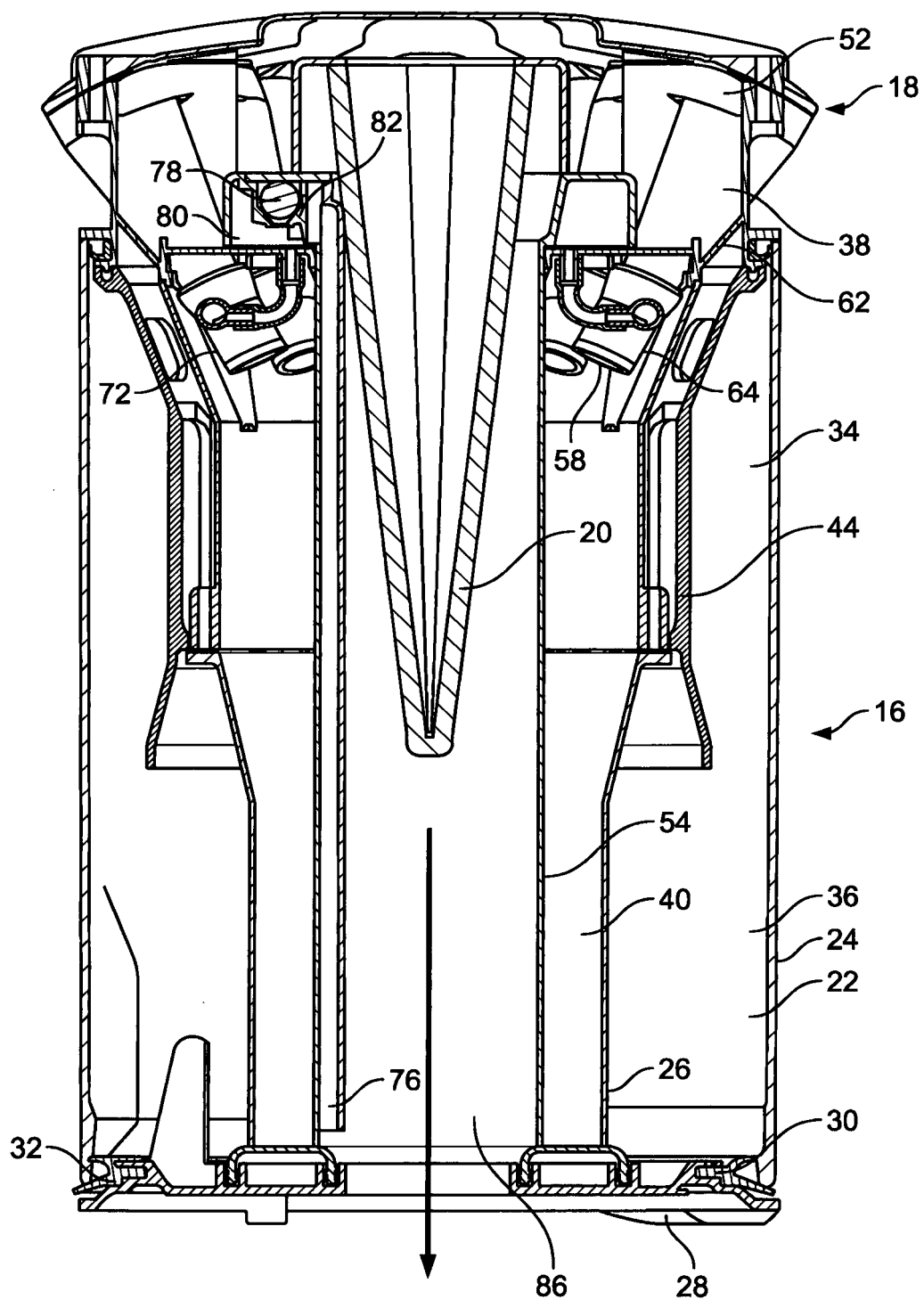


FIG. 6b

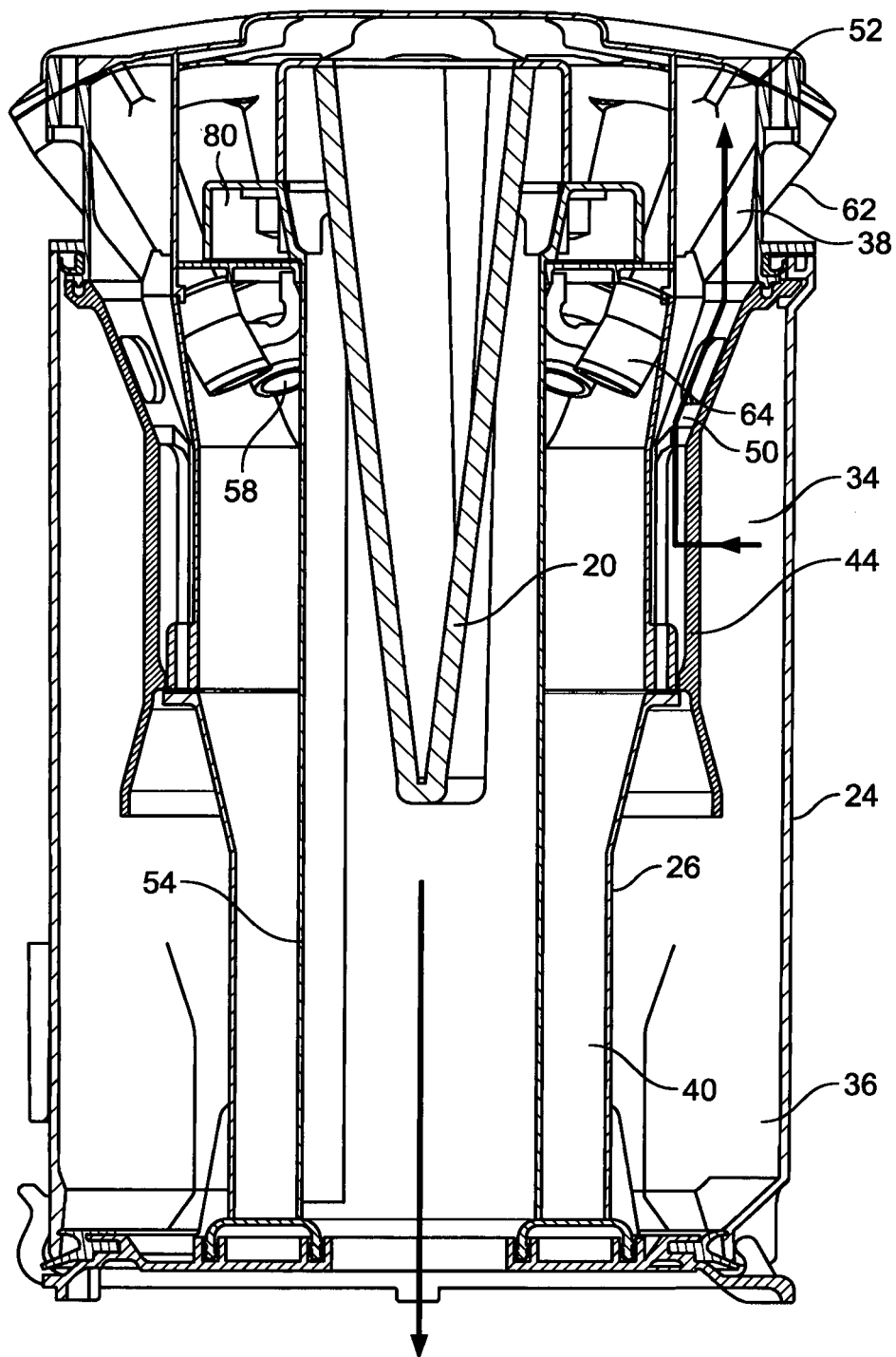


FIG. 6c

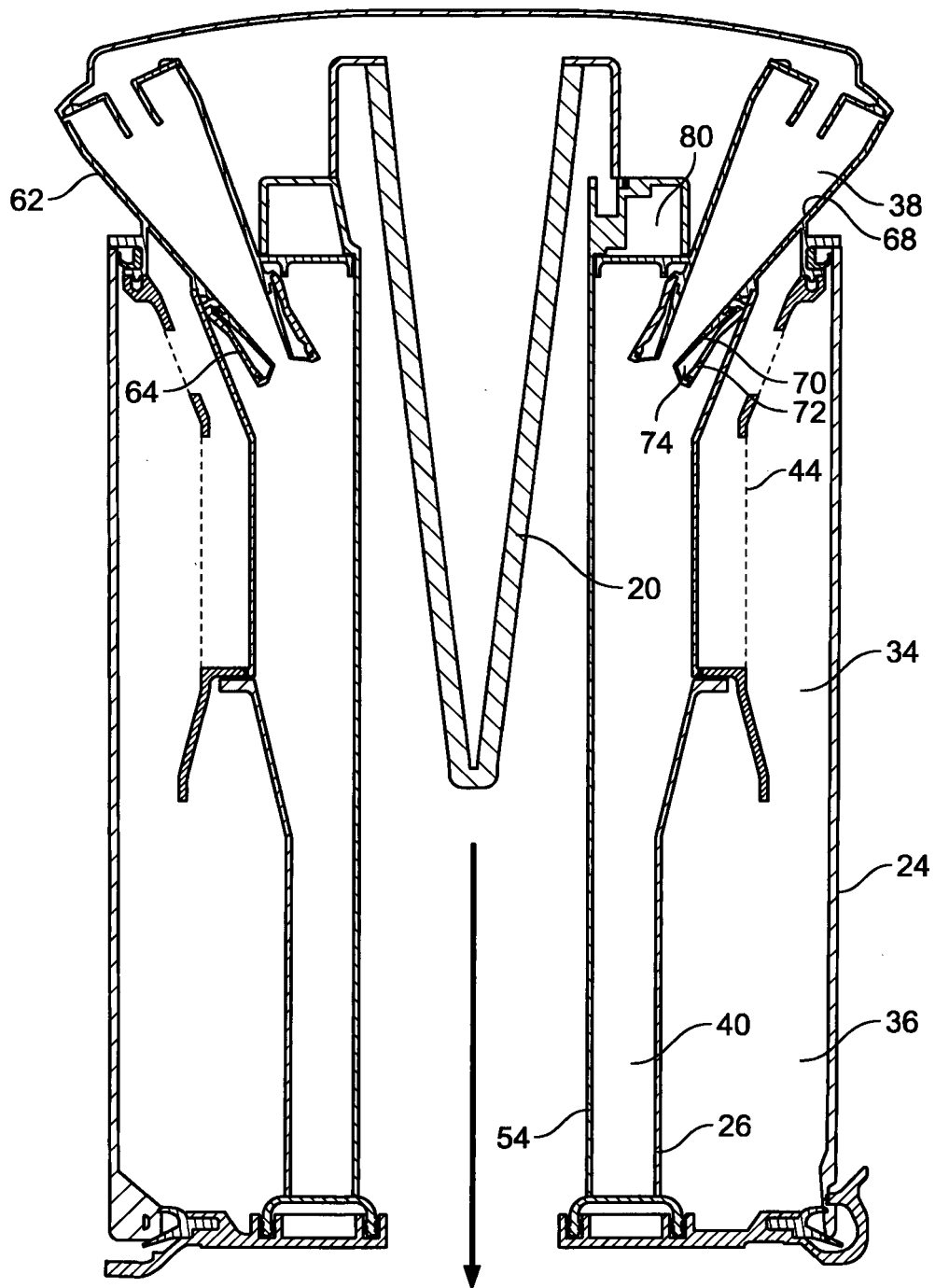


FIG. 6d

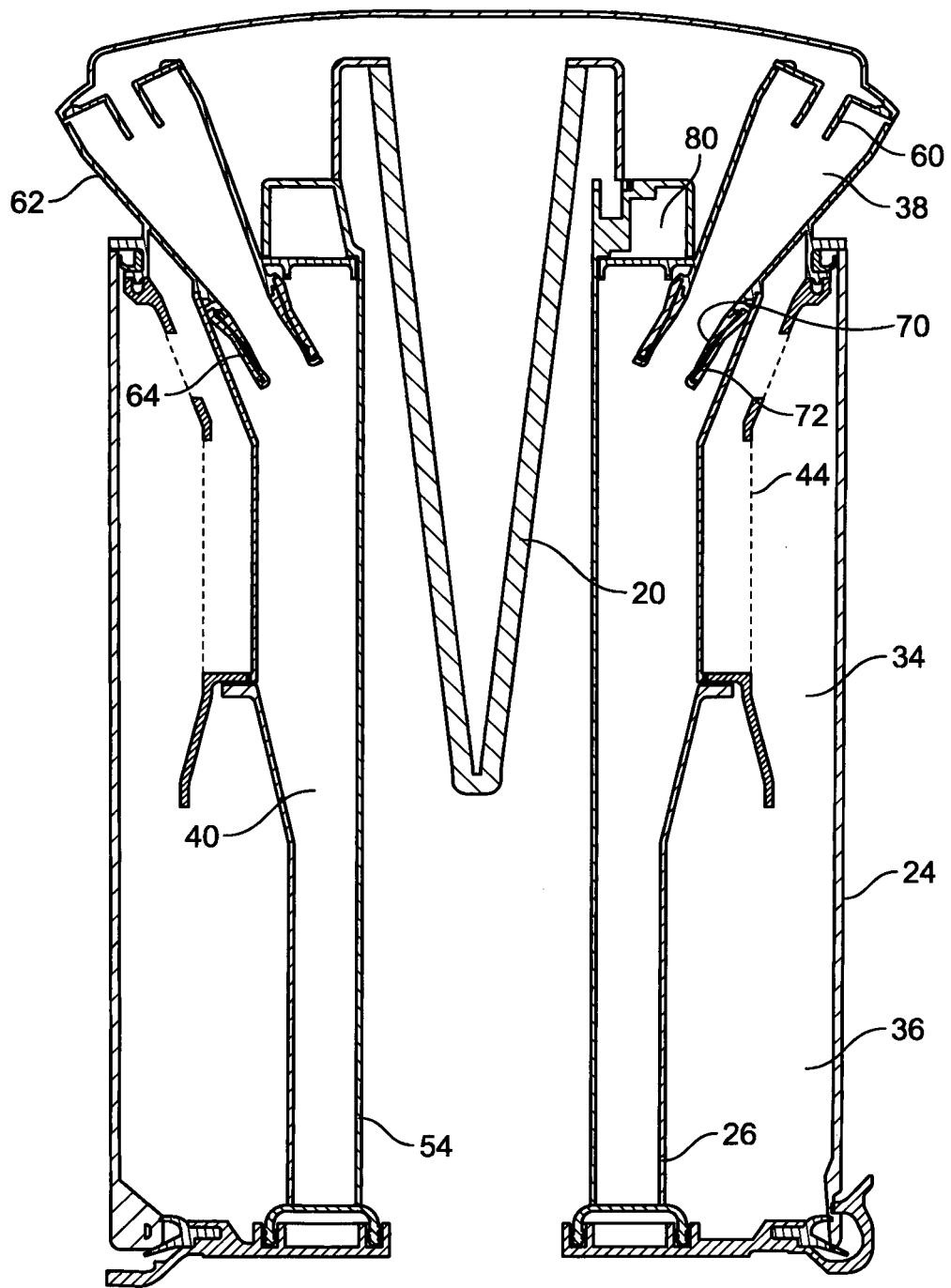
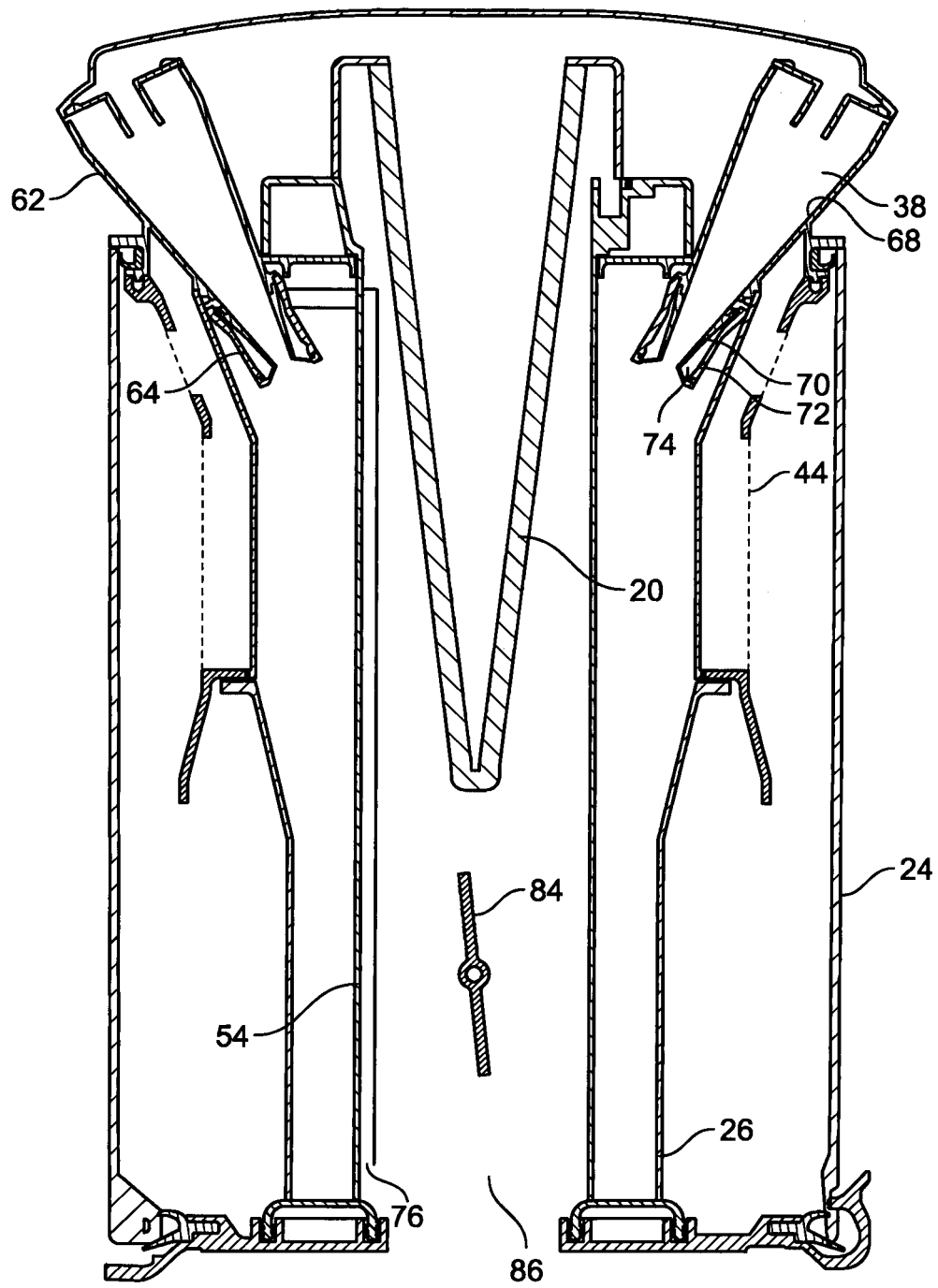


FIG. 6e



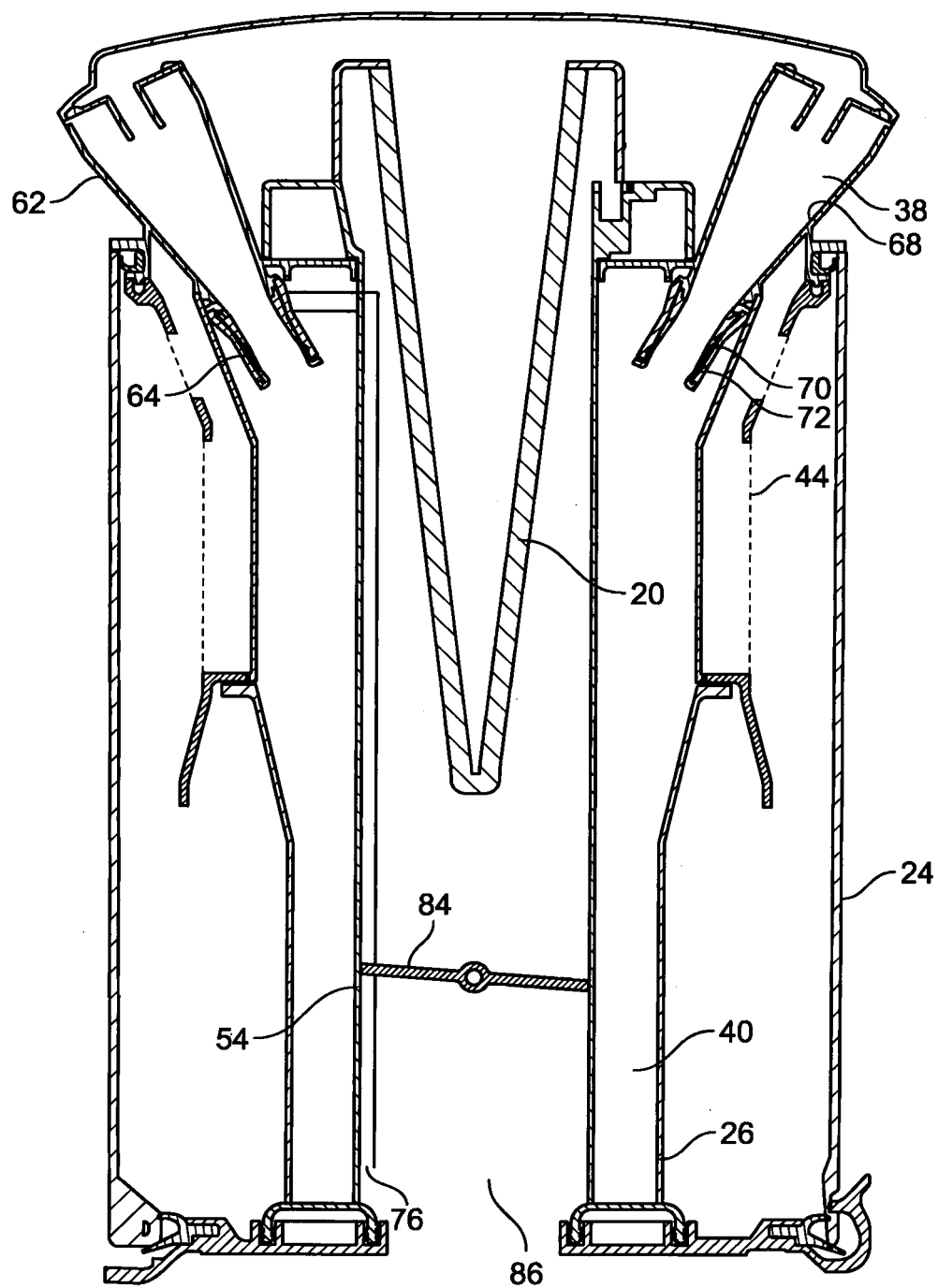


FIG. 7b

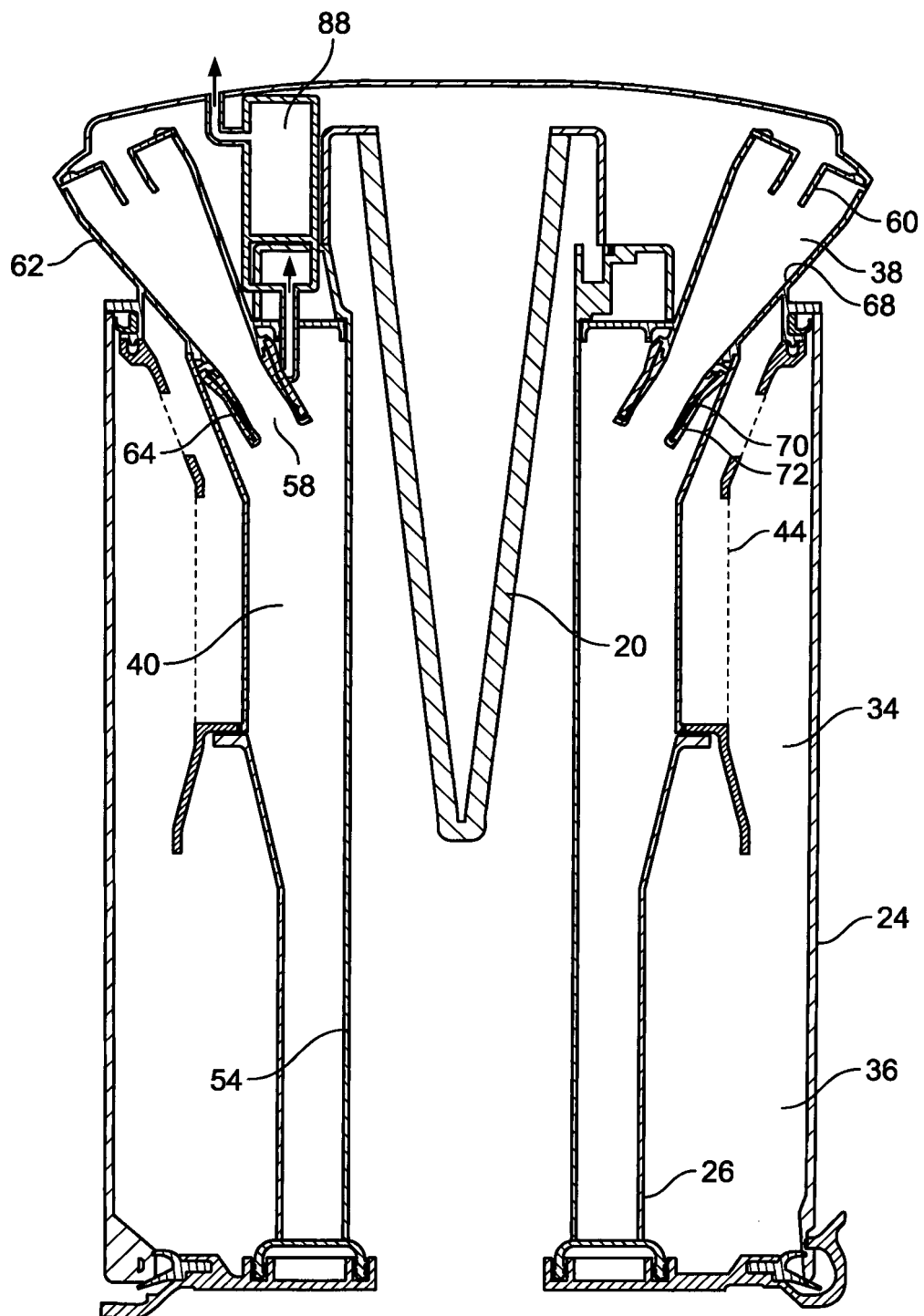


FIG. 8

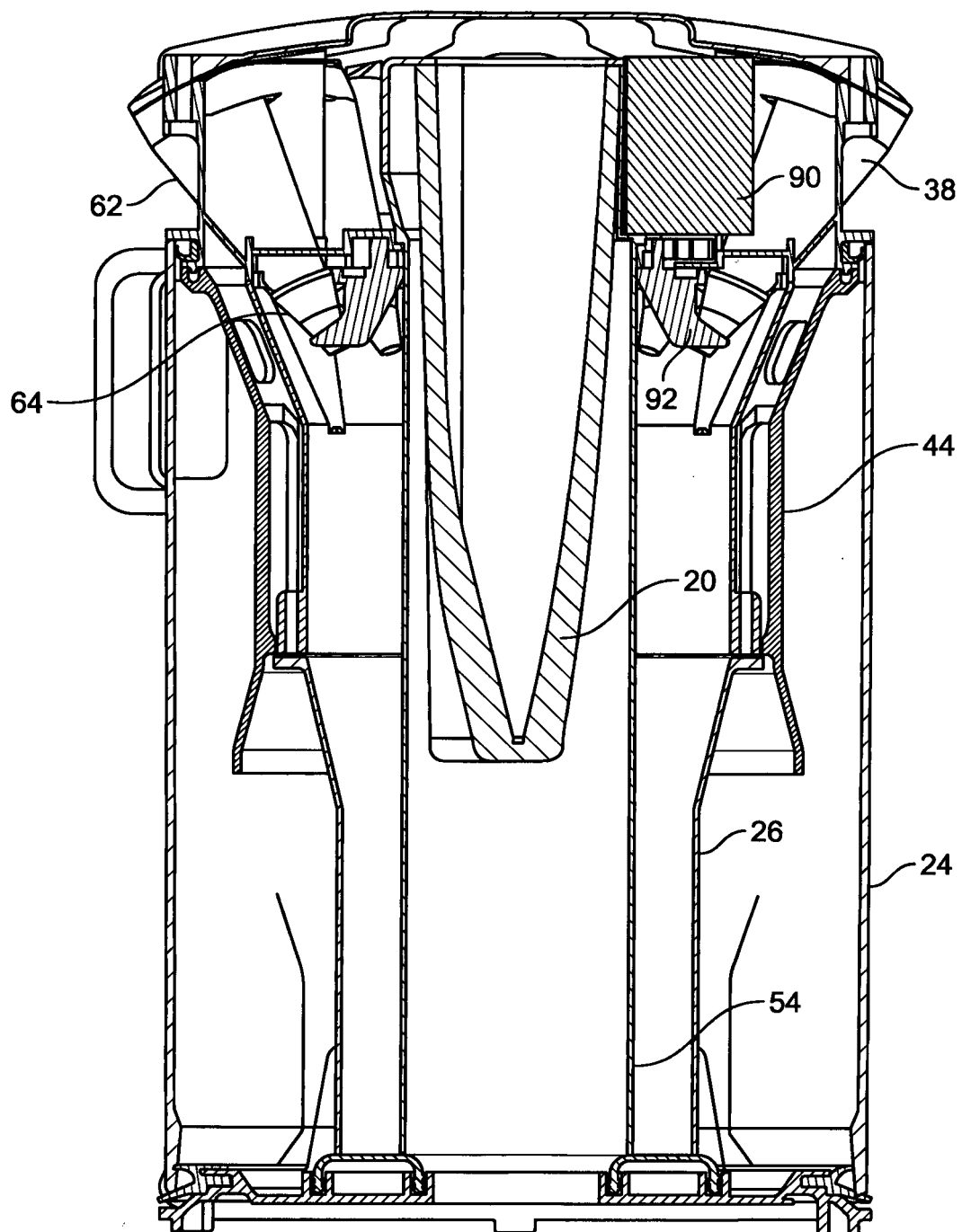


FIG. 9a

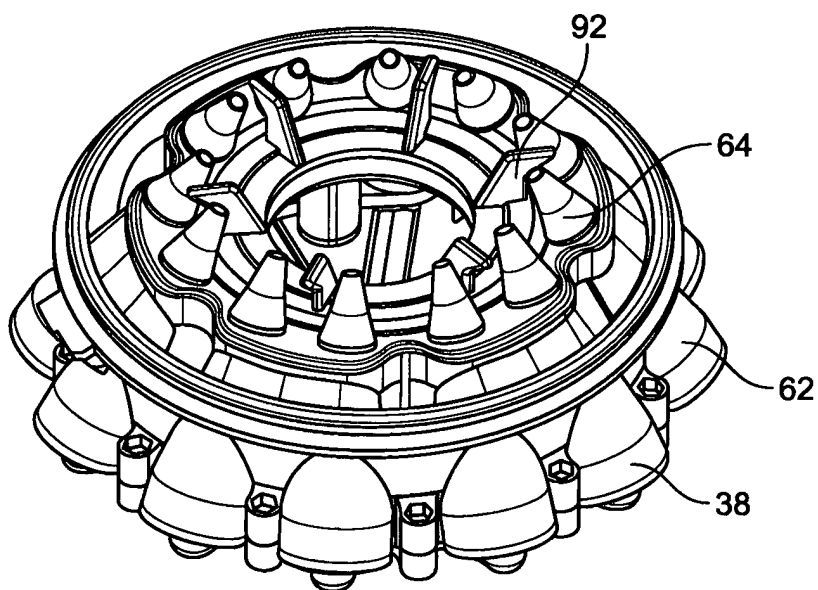


FIG. 9b

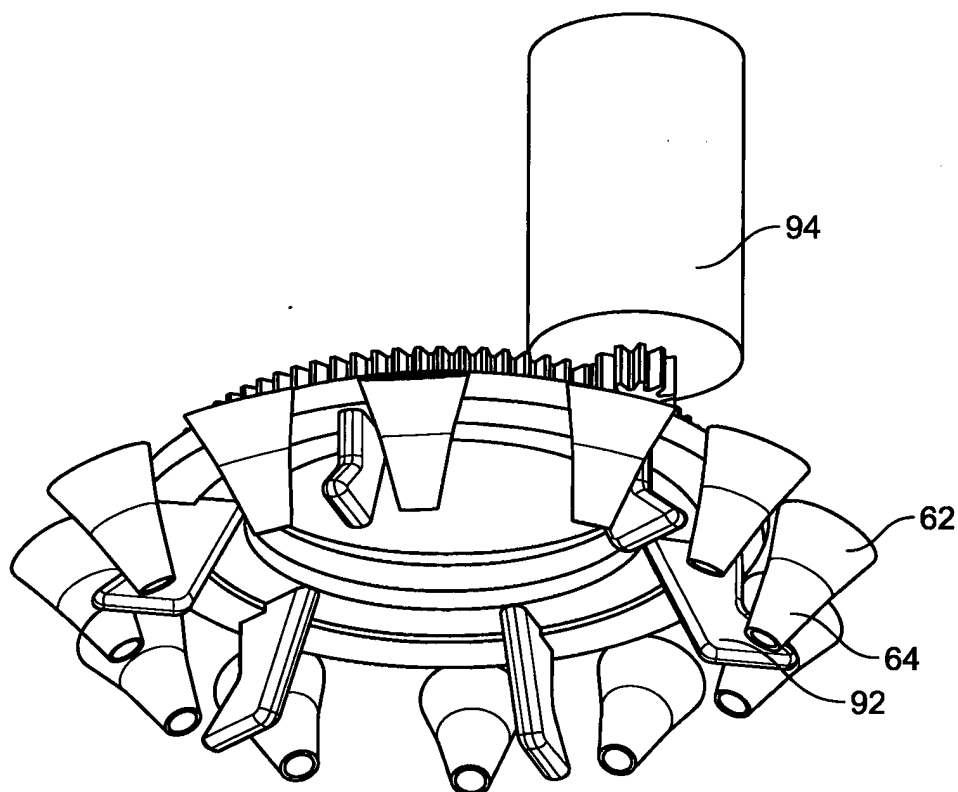


FIG. 9c

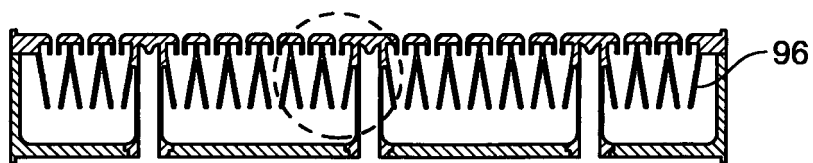


FIG. 10a

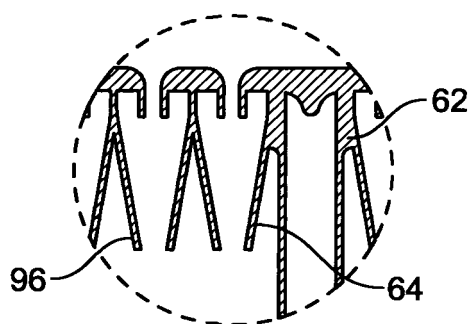


FIG. 10b

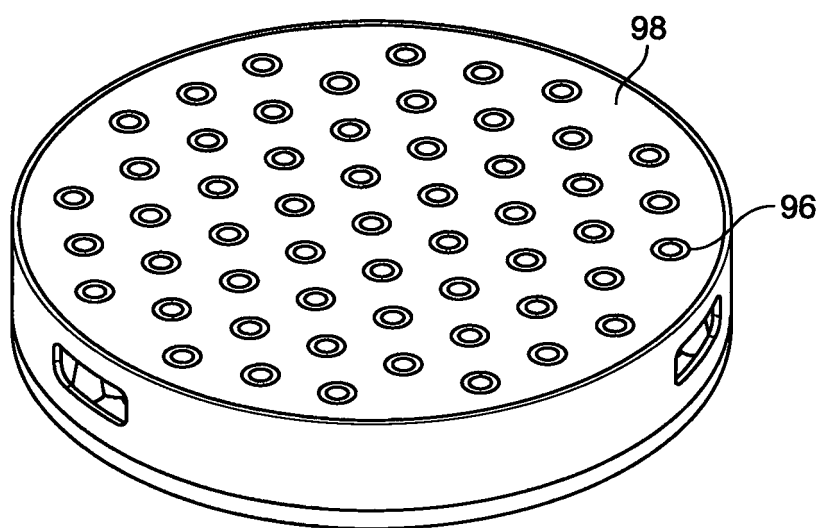


FIG. 10c

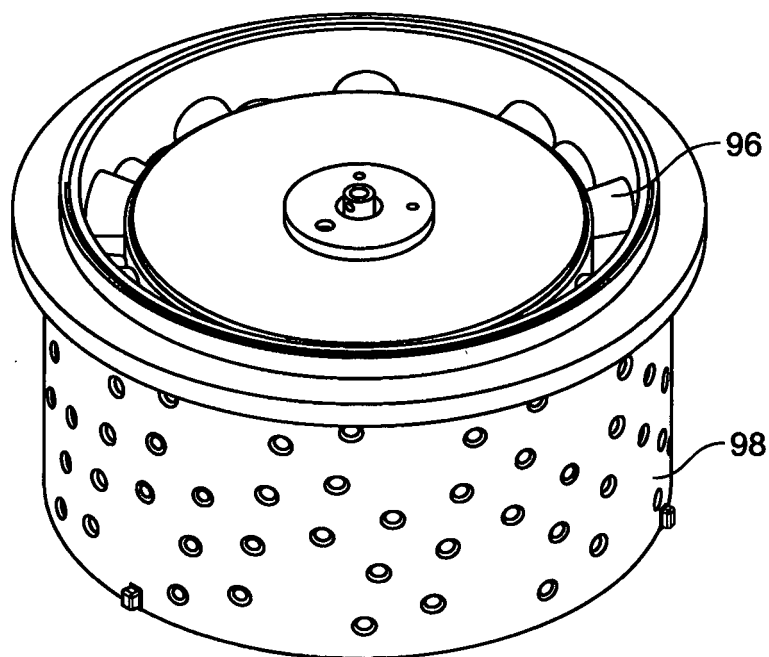


FIG. 11a

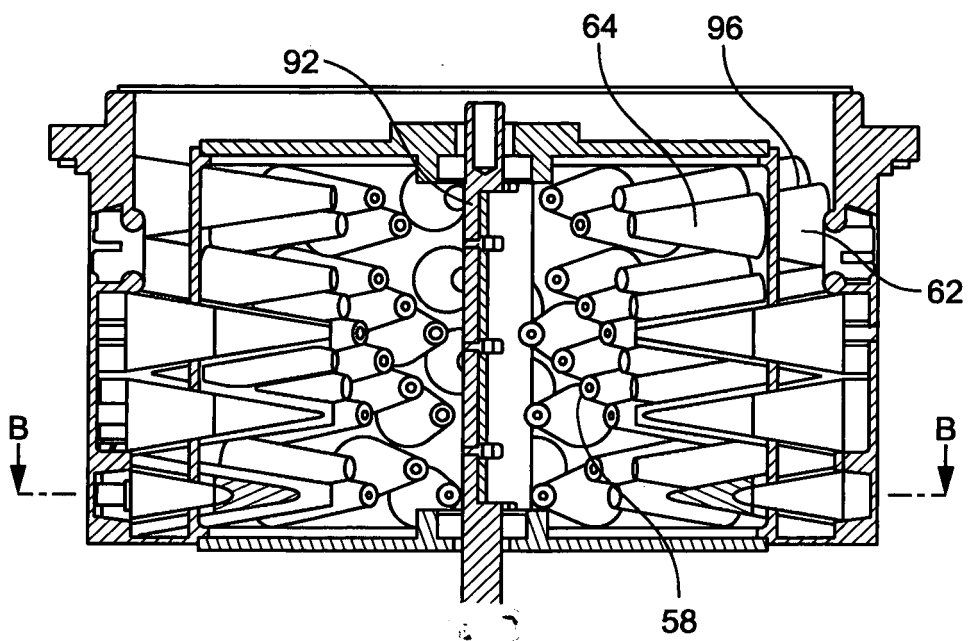


FIG. 11b

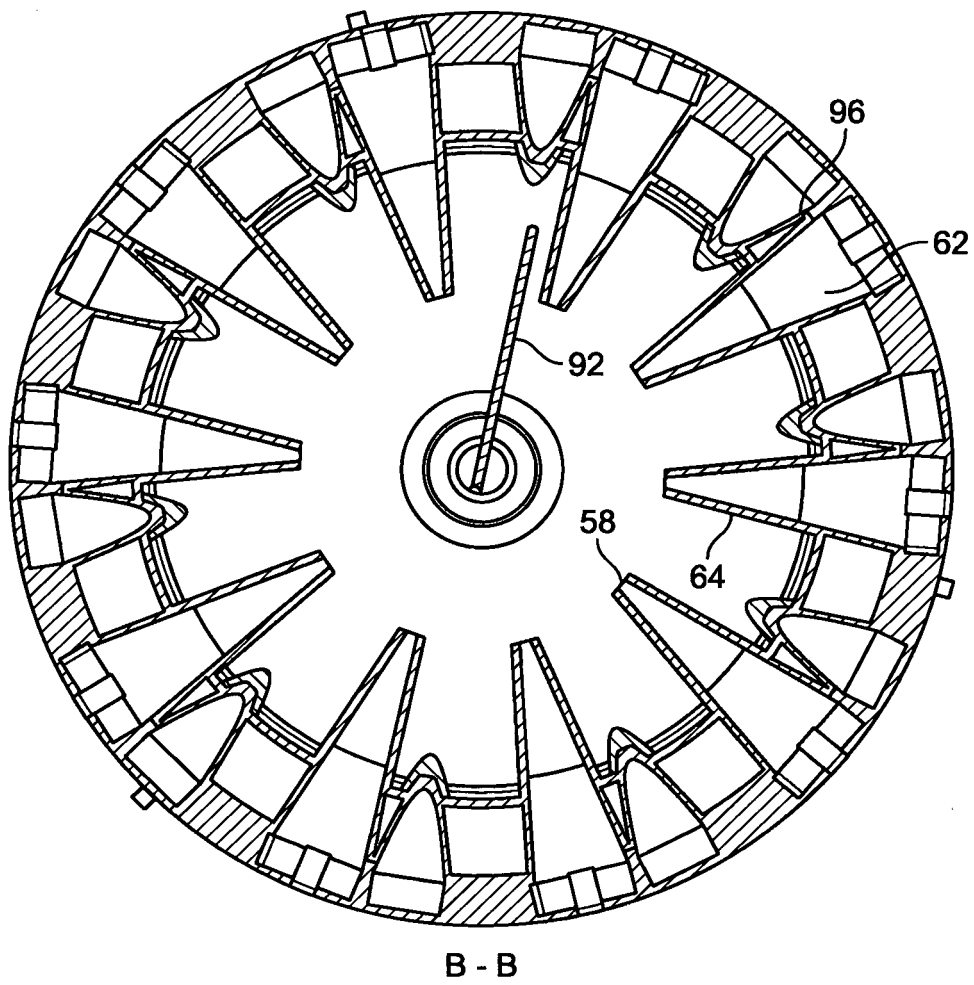


FIG. 11c

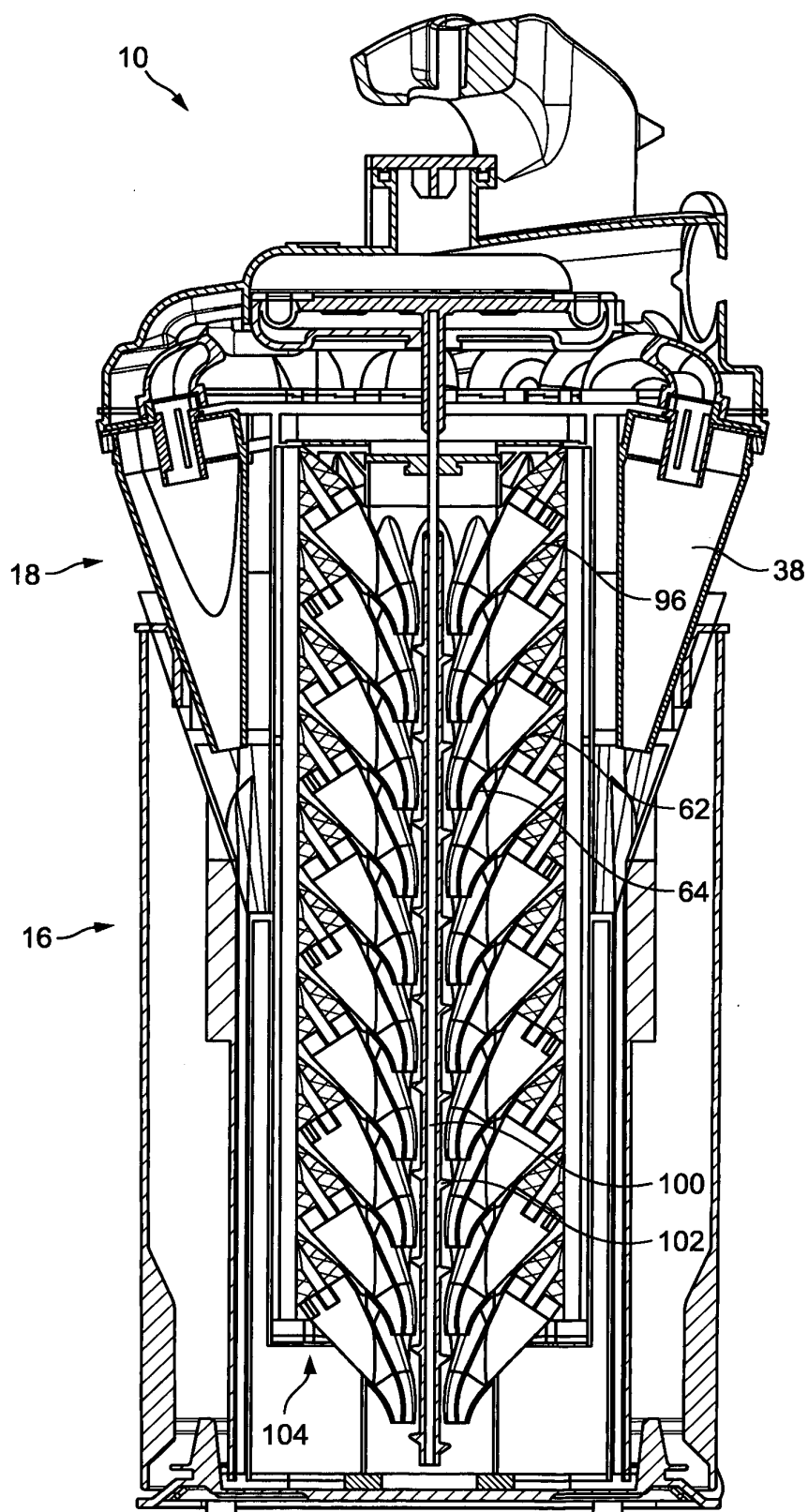


FIG. 12

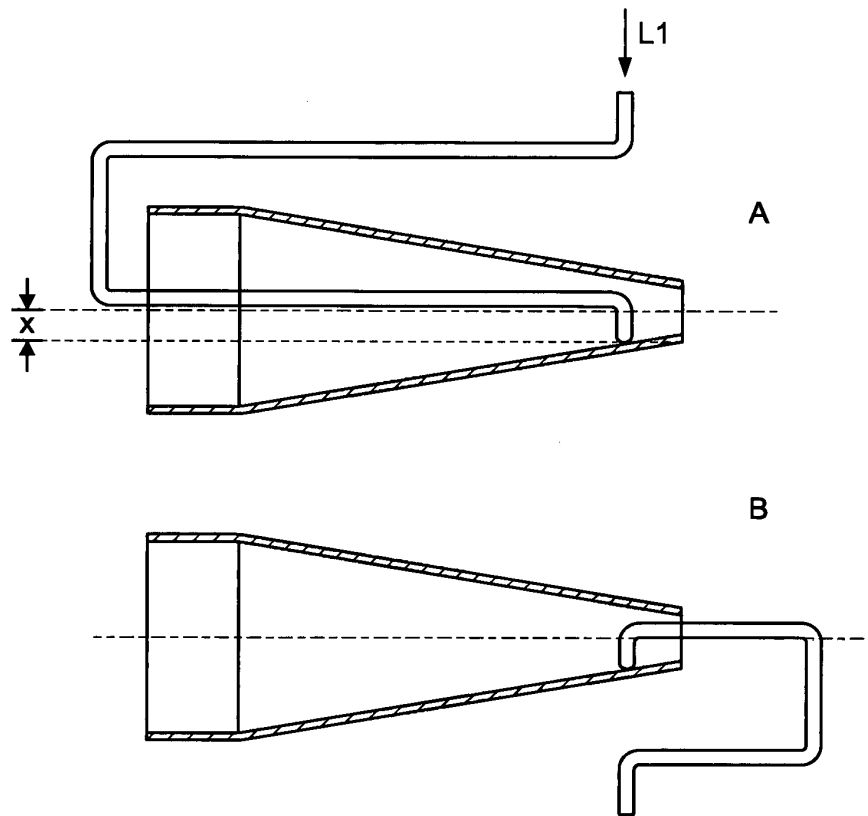


FIG. 13a

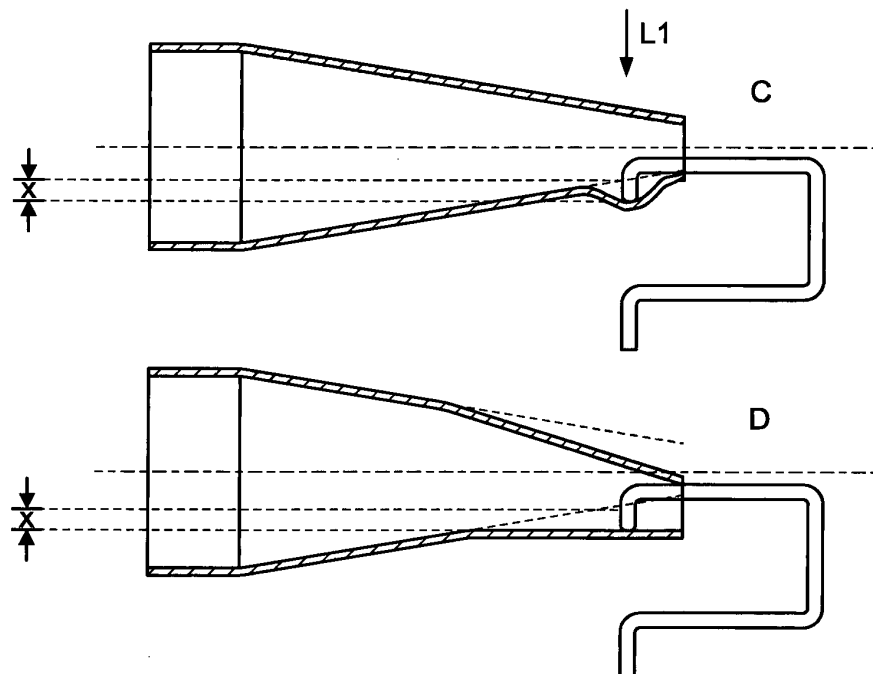


FIG. 13b

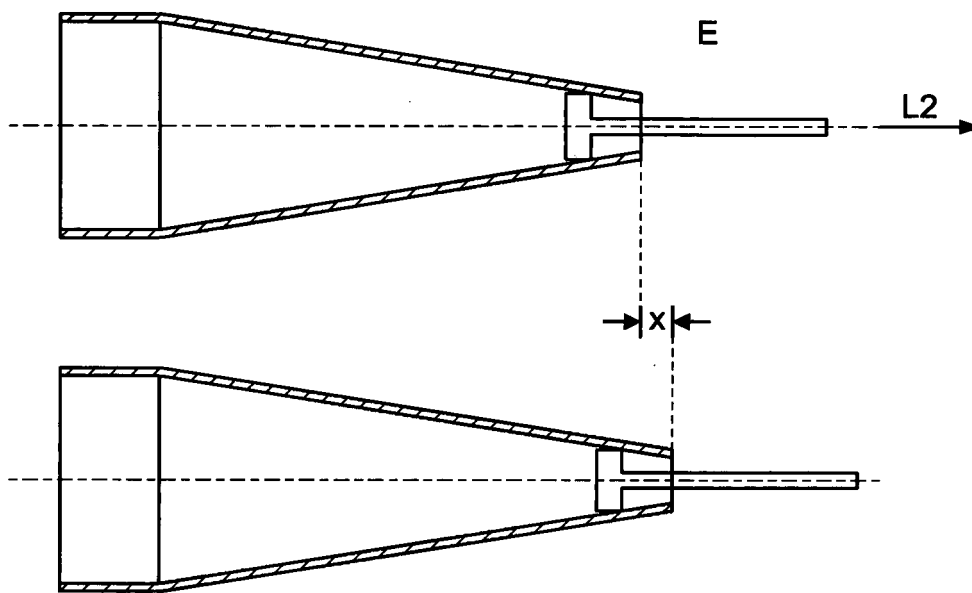


FIG. 13c

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 0042723 A [0003]
- US 251380 A [0005]
- EP 0476169 A [0005]